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Sea Frontiers

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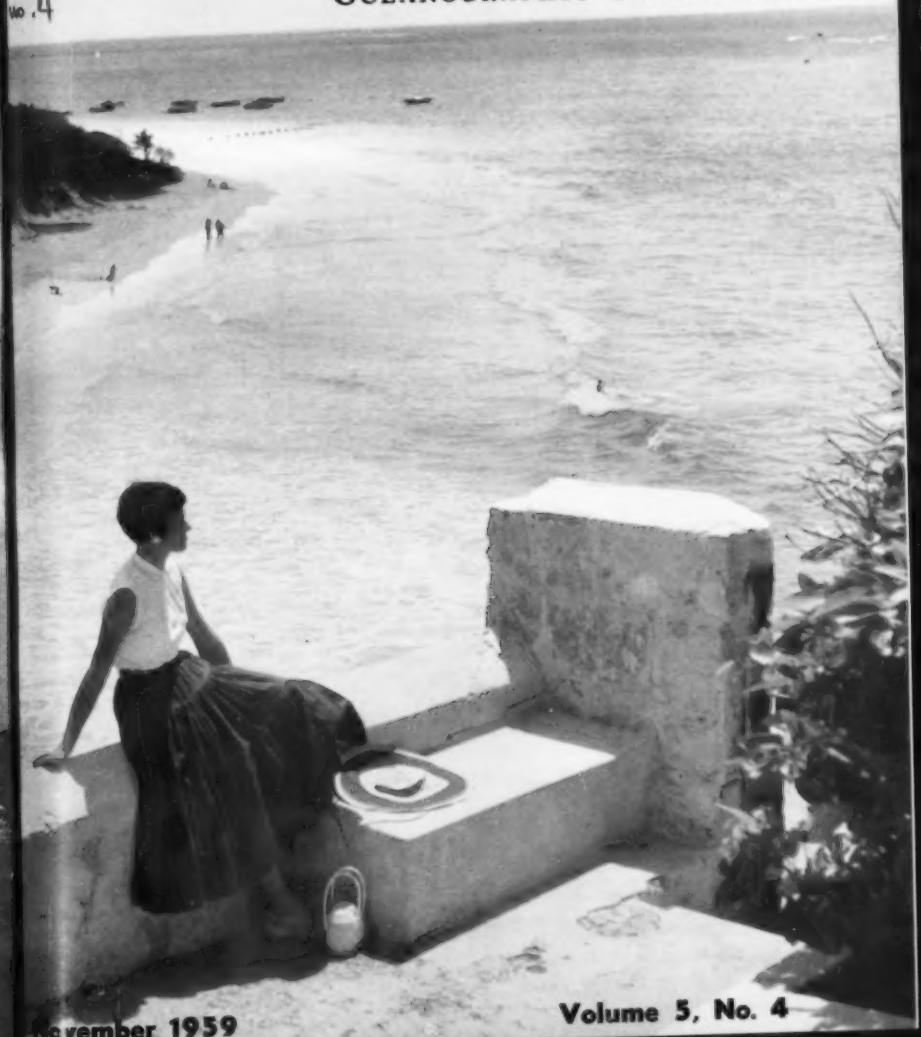
Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION



November 1959 Volume 5, No. 4

ANYONE LOSE SOME DENTURES? *Although they look like teeth, these are really two plates of the chiton, or coat-of-mail shell, found along the Great Barrier Reef of Australia. The "teeth," which have nothing to do with eating, insert into cartilage which forms a flexible link between overlapping plates. When detached from a rock, the chiton can curl up like an armadillo, the plates protecting the soft under parts. (From A. Pilkington)*

FRONT COVER. TO THE CASUAL OBSERVER *this scene appears to be only a pretty seascape of sun, sand and sea. But this border area between water and land is one of the most fiercely-contested battlegrounds in nature, with birds, fishes, amphibians and other creatures preying upon one another in the unceasing struggle for survival. (Pan American World Airways System)*

BACK COVER. TALLEST IN AMERICA, *Cape Hatteras Lighthouse sends its friendly beam far out over the Banks, whose racing tides, treacherous shoals and stormy weather have taken a heavy toll of Atlantic shipping. Nearby are the crumbling foundations of an earlier beacon, built in 1794 and damaged by Federal guns in 1861. (State of North Carolina photo)*

SEA FRONTIERS

Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION

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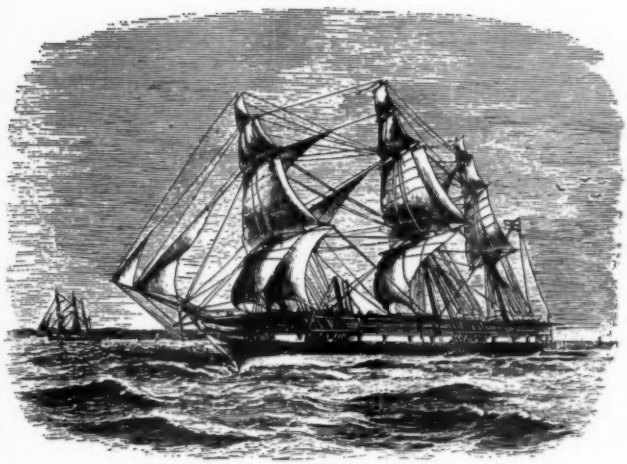

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IN THE AUGUST *setting of the General Assembly Hall of the United Nations, New York, the First International Oceanographic Congress discussed many of the latest developments in marine science and oceanic exploration, in September, 1959. Mr. Philippe de Seynes, UN Under-Secretary for Economic and Social Affairs, welcomes the scientists on behalf of the UN Secretary-General. (United Nations)*

Oceans in Review

ONE OF THE FIRST reports on the International Oceanographic Congress appeared, oddly enough, in the *New Yorker* magazine which, with its usual dry humor, interviewed an English plankton biologist and a professor of zoology from Nigeria. Quite clearly, if no other purpose was served, the Congress succeeded in awakening public curiosity about the activities of seagoing scientists.

The international outlook of marine science was well demonstrated by the many nations represented at the Congress. Animated but amicable scientific discussions in a variety of languages continued outside of the regular meetings, as delegates met in the lounges and corridors of the United Nations Building. Russian, Japanese, German, French and the Scandinavian languages were well represented along with English and Spanish, to mention only a few.

Apart from the scientific meetings, much informal exchange of ideas and information took place as visitors thronged aboard the research vessels

ocked in New York. Largest of these as the 6,000 ton Russian ship *Lomonosov,* by the side of which *Atlantis,* from Woods Hole, the French vessel *Calypso* and others appeared relatively insignificant.

Over 500 Scientific Papers

To report on the meeting in detail is impossible, since over 500 scientific papers were read and over 1,100 scientists attended. New ideas were presented and competent summaries of the present state of knowledge in various fields of research served to bring together much scattered information and to provide a focal point for further studies. Some of these summaries, delivered in the morning seminars were sufficiently startling to awaken the interest of the daily press. These will be briefly noted here. Later issues of *Sea Frontiers* will devote a special series of articles to some of them.

Oceans Born in Continental Splitting

One of the first sessions involved the basic question of the origin of the oceans and of the sea floor. Recent evidence has shown that the great mountain chain running north and south down the center of the Atlantic Ocean sea floor is continuous with similar ridges extending into the Indian Ocean and from thence between Australia and Antarctica, across the Pacific to western South America.

These mountain ridges contain rock from far below the earth's crust and may cover world-wide cracks in the surface of the earth. They may indicate that the continents were not always separate, but that a great world-

SYMBOL OF RUSSIA'S *expanded oceanographic program is the 5,960-ton* Mikhail Lomonosov *which was open for inspection by the delegates to the Congress in New York. Nearby research ships of the free world looked small in comparison. (U.S.S.R. Photo)*

wide land mass was once split apart and that the gaps between the continents thus formed became the ocean basins.

At another session it was shown that storms can be located in far away places by a careful measurement of tiny waves, a fraction of an inch in height, which run out beyond the storm to as much as 8,000 miles. At the same session, meteorologists described the exchange of heat and water vapor between the sea and the air The joint action of sea and air acts like a giant steam engine, carrying energy from the tropics to the colder regions.

Origin of Life

The question of how life originated from minerals, water and gasses in the earlier days of the earth's history has long been a fascinating problem and some new light was thrown upon this. Dr. Bernal of the University of London, substituting for the Russian scientist, Dr. Oparin, provided a logical and stimulating account of a possible life origin, connected with the ocean. The carbon compounds, necessary

precursors of life and derived from deep rocks, may have floated to the sea surface and then become absorbed on the clay minerals of beaches in the form of an oily scum. The comparative lack of oxygen in the early atmosphere, higher temperatures and perhaps increased radioactivity may all have helped to produce the amino-acids and proteins that are the building blocks of living matter.

When and from Where Did Sea Water Come?

It is taken for granted that the oceans are filled with sea water, but the inquiring scientist is not satisfied. He wants to know whether it was always there or whether it came to the sea gradually. One of the theories advanced is that the water was gradually squeezed out of the rocks and that chemical changes have taken place in it during its long history.

Less Knowledge of Sea Floor Than the Moon

In addition to the main business of the Congress, committees met to discuss a brand new plan for cooperative exploration of the Indian Ocean, with research ships from several nations participating. It has often been noted that we know less about the floor of the Indian Ocean than we know about the visible surface of the moon. Perhaps mice and even men will be landed on the moon before this lack of

PROBLEMS CONNECTED *with the origin of the vast unknown ocean depths, and the latest progress in the marine sciences, were discussed at a press conference during the First International Oceanographic Congress, United Nations. Prof. Haakon Mosby (right), of Norway, answers a question while Professor Roger Revelle, United States, President of the Congress, listens. (United Nations)*

knowledge is corrected, but at least an effort is being made.

Puncturing Earth's Skin

Project Moho, which proposes to drill through the earth's crust at its thinnest part, either in the Puerto Rico deep or near the Clipperton Islands in the Pacific, came up for discussion. This ambitious proposal, involving an 18,000 foot borehole under several thousand feet of ocean water, will, for the first time, give direct information about the nature of the earth's skin.

Elsewhere in this issue is the account, by a participating scientist, of the preliminary work necessary in selecting the Moho site, involving the measuring of waves set up by explosive charges at sea.

The question of life in the sea today was covered by topics such as the rate at which plant life grows and the potential food yield of the oceans. The behavior of fishes in response to lights, electric fields and other stimuli were regarded as potential openings for cheaper and faster production of fish food, although at the Congress the emphasis was upon basic research rather than the applications of it to industry.

Whales Known by Blood Types

It was reported that whales may now be distinguished just as human beings are, by their blood types. This is also true of fishes, seals and other sea creatures. Thus it should now be possible to trace the movements of sardines or herrings, since the blood types may vary from one group of fishes or location of schools to another.

More detailed stories based upon the findings reported at the Congress have been planned for *Sea Frontiers*, wherever possible written by the scientist who gave the original report. It is hoped that these authoritative articles will, in some measure, convey the excitement that drives the oceanographer in his search for an answer to the many problems of that layer of the earth's surface which lies below the oceans.

Up-to-Date Marine Science Museum

Members of the public taking guided tours of the United Nations Building were impressed by exhibits of oceanographic instruments, deep sea cameras and photographs, and colored diagrams explanatory of the marine sciences and their problems. This marked interest encourages the Foundation in its planning eventually to establish a modern marine science museum in a location where it will be available to the greatest number of people.

Apart from the exciting themes and ideas presented, the considerable number of non-oceanographers attending the meeting must have been impressed by the singleness of purpose shown by the oceanographic scientists, including those from behind the Iron Curtain. This is a healthy extra dividend arising from the study of our common ocean. It is not too much to hope that universal curiosity about the waters joining us may play its part in restricting the inventive energy of all nations to peaceful purposes.

SQUINTING IN THE UNACCUSTOMED *tropical sunlight, the Russian delegates to the International Oceanographic Congress pose before the entrance of The Marine Laboratory, University of Miami, and the headquarters of the International Oceanographic Foundation. In the back row, sixth from the left, stands Dr. Hilary B. Moore, assistant director of The Marine Laboratory, and, fourth from the right, Dr. C. P. Idyll, chairman, Department of Marine Sciences, who acted as guides for the group during its tour of this largest tropical and subtropical marine station. (E. John Long)*

Russians Visit Marine Lab. and I.O.F.

Russian delegates to the International Oceanographic Congress made only one major trip outside of New York. With the permission of the U.S. State Department, on September 8th, a group of twenty scientists visited The Marine Laboratory, University of Miami, where I.O.F. has its headquarters.

Of the twenty, ten were biologists and ten were experts in the physical aspects of oceanography. None was an authority on tropical or subtropical marine work, but they were intensely interested in seeing and learning about the research being done by The Marine Laboratory, the largest marine institution in the tropics.

In the absence of Dr. F. G. Walton Smith, director of the Laboratory, who was attending the Congress in New York, the Russian group was greeted by Dr. Hilary B. Moore, assistant director; Dr. C. P. Idyll, chairman, department of marine sciences; Dr. G. L. Voss, curator of invertebrates, mammals and fishes, and Capt. E. John Long, representing I.O.F. Most of the visitors spoke some English, and a tour conductor helped to bridge the lingual gap for others. Members of the laboratory staff were

particularly impressed with the friendliness of the visitors, and their willingness to discuss their own scientific activities.

Those in the group and their affiliations were:

Mr. K. O. Lange, director of the delegation; Mr. P. L. Bezrukov, Mr. M. E. Vinogradova, Mrs. A. P. Zhuze, Mr. O. I. Koblentz-Mishke, Mr. A. P. Lisitzin, Mr. O. B. Mokyevskiy, Mrs. L. A. Ponomoreva, and Mrs. G. I. Semina—all of the Institute of Oceanography, Academy of Sciences.

Mr. A. B. Zhivago, of the Institute of Geology, Academy of Sciences. Mrs. Z. G. Shchedrina, of the Institute of Zoology, Academy of Sciences.

Also Mrs. N. G. Ninogradova, Mrs. N. A. Lisitzina, Mrs. Z. A. Filatova, Mr. P. V. Ushakov, Mr. V. A. Magnitskiy, Mrs. L. P. Krilova, Mr. V. B. Porfir'ev, Mr. V. L. Maksynchuk, and Mr. Kasim Gul. Mr. Boris Oblesow was tour escort and translator.

Congress Considers Oceanography

For all mariners, and particularly those interested in the scientific exploration of the sea, the last great frontier on earth, a bill introduced in the First Session, 86th Congress, has possibilities and significance which can scarcely be exaggerated.

Known as S. 2692, the bill's preamble reads as follows: "To advance the marine sciences, to establish a comprehensive ten-year program of oceanographic research and surveys; to promote commerce and navigation, to secure national defense; to expand ocean resources; to authorize the construction of research and survey ships and facilities; to assure systematic studies of effects of radioactive materials in marine environments; to enhance the general welfare; and for other purposes."

The bill has been referred to the Committee on Interstate and Foreign Commerce, of which Senator Warren G. Magnuson is chairman.

The bill aims at advancing the recommendations of the Committee on Oceanography and Project TENOC of the Office of Naval Research. It is another forward step in the efforts of the free world to know more about the largely unexplored domain now being vigorously studied by the Soviets. Few Americans and others in the free world realize that, in addition to the progress being made in space travel and rocketry in the U.S.S.R., the Russians also have a fleet of the largest oceanographic vessels in the world today, and a full program of marine research.

Members of the I.O.F. and others who wish to show their support of S. 2692, and similar efforts of the Congress to promote marine research, have been invited by Chairman Magnuson to send their comments and criticisms to the Committee's headquarters, Room 5108 New Senate Office Building, Washington 25, D.C.

BRAHMAN AND FRIEND, *Kissimmee, Florida. Science and the sea have roles in the health of cattle in the southeastern United States, where the pesky screwworm once took heavy toll. Ground whalemeat is used in the mass rearing of screwworm flies, which are then exposed to gamma ray irradiation and released. Thus sterilized, the eggs produced by these flies are sterile, and the screwworm is well on its way to being eliminated east of the Mississippi River. (Florida State News Bureau)*

Whale Attacks Fly

By A. U. SPEAR

IT MAY SEEM that whales roaming cold Antarctic seas are worlds removed from that sizzling beefsteak on your home dinner table, but the two have a connection—"whaleburgers."

Millions of pounds of ground whale meat are today being used as part of the diet for billions of fly larvae being raised at Sebring, Florida, and thus provide "ammunition," which, by an ingenious plan, is used to wipe out the pesky screwworm, scourge of the cattle ranches raising quality beef in the Southeastern United States.

Kill a Steer in Ten Days

In nature, the screwworm, which is actually the larva of the blowfly *(Callitroga hominivorax)*, eats the living flesh of any warm-blooded animal having a wound or cut on which the female fly can deposit her eggs.

An untreated infestation of screwworm can kill a full grown steer in less than ten days. Other, smaller animals are likely to die even sooner. Wildlife becomes infested, too, in an area populated by the insect. Screwworm ravages in the southeast have cost livestock raisers up to $20 million a year, and wildlife has paid an unestimated toll to the vicious pest.

Gamma Rays from Cobalt-60

Now, thanks to an intensive campaign being carried out by the Screwworm Eradication Program of the Florida Livestock Board and the U.S. Department of Agriculture, the screwworm is well on its way to being eliminated east of the Mississippi River. Whale meat plays an important role in mass-rearing more than 50 million flies each week. These are sterilized, at the Program's headquarters in Sebring, by exposure to gamma ray irradiation from Cobalt-60, and then dispersed by planes over many thousands of square miles.

Both sterile males and females are released from the planes, but it is the sterile males which cause reduction in the numbers of the native fly population. When a sterile male mates with a fertile native female, the eggs are sterile and will not hatch. The female fly mates only once, but the males are known to mate a dozen times or more.

Overwhelming Native Males

The eradication theory is based on dispersing sufficient sterile males per square mile to overwhelm the native male population. Thus, more and more sterile males are available to mate with the diminishing number of fertile females until finally no reproduction of flies occurs and the pest is wiped out.

Since July, 1958, when the big mass-rearing laboratory was opened for a full-scale production, through September, 1959, more than 4 million pounds of whale meat have been consumed in rearing 3,400,000,000 screwworm larvae. During that period sterile flies numbering nearly 3 billion were dispersed by planes flying over

THE REARING FLOOR, *Sebring, Florida, where some 1,000 vats produce 50 million sterile flies weekly for the State-Federal Screwworm Eradication Program. Of the 40 tons of ground meat, used each week to feed the larvae, about 75 per cent is whalemeat. (State-Federal Screwworm Eradication Program)*

as much as 84,400 square miles including most of Florida and parts of Georgia and Alabama.

The difference between larvae reared and flies dispersed is accounted for by normal mortality plus diversion of about 10 per cent of pupae harvested to the fertile fly colony where eggs are produced for the rearing process.

Diet of the larvae, or maggots, being reared to produce the sterile flies is ground meat, blood and water. For 50 million flies a week, food requirements are 40 tons of meat, 4,500 gallons of whole animal blood, and about 9,600 gallons of water.

Begin with Horse Meat

Horse meat is used for the first couple of days, and then the food is switched to whale meat. Apparently the larvae are not aware of any change. Feeding time on the rearing floor is about five days, during which spent food is removed from the heated rearing vats, and new food added.

Specifications for whale meat used for fly rearing, and purchased on open bids, require the meat to be ground, trimmed of excess fat, large tendons and connective tissues, and limited as to moisture content 72-76 per cent; protein 18-20 per cent; and fat 5-7 per cent.

Fatty or oily meat in the worm diet is undesirable. Consequently, only certain types of whale, preferably the fin whale of Antarctic waters, produces meat of the quality desired. Japanese whalers bring it to Miami, where a processing plant converts the frozen whale meat into cakes or "whaleburgers," and delivers it by truck to Sebring.

In a continuing effort to reduce production costs, scientists in the program's Methods Development department have recently intensified research on screwworm nutrition. Results have been encouraging. Latest development is an increased use of whale meat by grinding it finer and adding cottonseed hulls to give a more satisfactory texture.

Latest research indicates, also, the use of whole ground rough fish may

THIS COBALT FACILITY, *at Sebring, Florida, the largest single concentration of radiation energy under the supervision of the U. S. Department of Agriculture, induces sexual sterility in more than 50 million screwworm fly pupae per week. Flies are then released from airplanes to mate with the native fly population and produce eggs which do not hatch. (Florida State News Bureau)*

provide an even cheaper food media.

Thus, ocean resources may be able to provide the greater part of a huge tonnage for rearing the insects which, in their natural state, are obligatory parasites on the living flesh of hundreds of warm-blooded domestic and wild animals.

Sea Urchins Aid Space Research

While it did not attract as much attention as the monkeys which were rocketed into space and safely recovered in April, an important experiment in egg fertilization took place on the same flight. The test was designed to yield evidence whether prolonged exposure to cosmic rays, weightlessness and other conditions of space travel could effect fertility.

For the experiment, the eggs and sperm of the sea urchin, one of the simpler marine organisms, were used. Encased in three separate vials within 10 ounce aluminum cylinders, the sperm and eggs were mixed before and during peak acceleration of the giant rocket's nose cone. Scientists hope to determine the effect of space-flight conditions on the fertilized eggs, on the fertilization process in a weightless situation, and on cell division.

The sea urchin is the classic animal for many experiments involving fertilization, not only because its eggs are comparatively large, but also because the egg division pattern is particularly plain.

Deeper In Fresh Water

Large vessels entering the St. Lawrence Seaway from the ocean will sink a bit! Nothing alarming, but rivers and lakes are less buoyant than the open sea.

For instance, a ship settles one foot deeper in fresh water for every 36 feet of draft. As the Seaway has a minimum depth of 27 feet, the larger craft using it may settle as much as eight inches as they leave salt water.

Conserving South African Fish

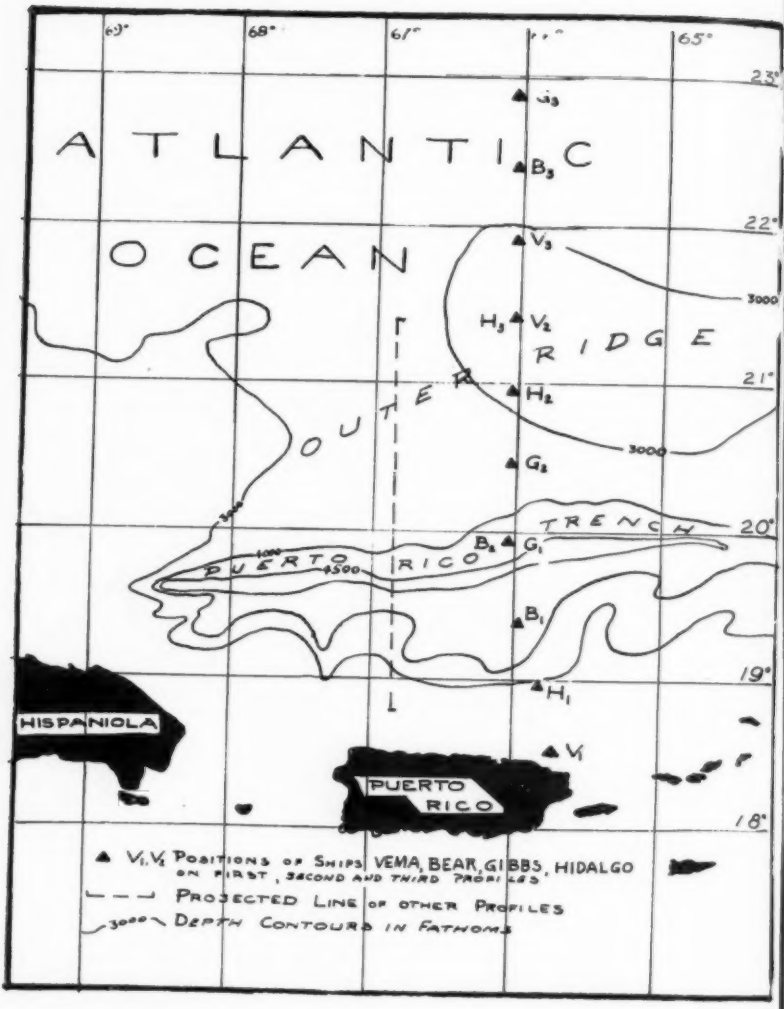
One of South Africa's most valuable resources, sea food, will benefit from a half million pound investment in ships and buildings, according to an announcement by the Union Division of Fisheries. Two vessels will collect biological and hydrological data out at sea, while others will work closer inshore on fish-tagging and blanket-netting. Additional laboratory facilities will be provided at Sea Point. A total of more than £15,000,000 has been invested in the fishing industry on the Union's west coast.

KNOCKING ON DAVEY JONES'S LOCKER! *The plume of spray shows where an explosive charge has just been detonated. The sound waves reflected from or bent by submarine rock layers far below are recorded via hydrophones, trailed on floating cables behind the boat. Calculations made from these records determine the thickness of layers in the ocean floor. (Courtesy Offshore Exploration Group, Inc.)*

Probing For "Moho"

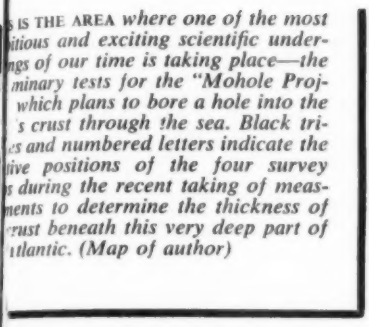
By T. R. GOEDICKE

MOONLIGHT dappled the whitecaps as the silent ship tossed on the waves, engines cut, waiting. Suddenly, the radio crackled on, and a compressed voiced gargled "Over the side —depth charges over the side!" In a few seconds came the muffled "ping" of the underwater explosion, and three figures on deck came to life. "Slack hydrophone cables," one commanded, while the other two at the railing deftly began paying out long coils of black cable that sank almost noiselessly into the water, punctuated only by the occasional "plop" of a float breaking the sea surface.



That sequence, repeated simultaneously at regular intervals aboard a small fleet of oceanographic research vessels, was the basic activity of a new excursion into the unknown—the recent Atlantic probe of the Moho.

Moho, short for Mohorovicic discontinuity, the boundary between the earth's crust and its mantle beneath, is vitally important to scientists who study the earth. The Moho investigations will lead up to a man-made puncture of the earth's crust and mantle that should settle once and for



S IS THE AREA where one of the most itious and exciting scientific under-ngs of our time is taking place—the minary tests for the "Mohole Proj-which plans to bore a hole into the 's crust through the sea. Black tri-es and numbered letters indicate the ive positions of the four survey s during the recent taking of meas-nents to determine the thickness of rust beneath this very deep part of tlantic. (Map of author)

all what the bulk of our planet is really made of.

Such a project—the drilling of a hole from the earth's surface completly through the crust into the mysterious inner substances—is well beyond the stage of conjecture. It has been dubbed "Project Mohole" and is considered to be vital to our understanding of the earth's processes of formation. Although Mohole was suggested almost as a joke, it is now serious scientific business.

Thinnest Earth Crust?

Any drilling of a Mohole into the earth, such as that tentatively scheduled for completion by 1962, will, of course, be done at the point where the crust of the earth is thinnest. Geologists and geophysicists have known for some time that beneath the continents the crust thickens, but that beneath the oceans it generally becomes thinner. Below the island of Puerto Rico, for example, the crust measures approximately twenty miles, whereas under the nearby ocean floor it varies between two and one half and four miles.

Based on the belief that the earth's crust is perhaps thinnest in the Atlantic Deep north of Puerto Rico, a well-named group which calls itself the American Miscellaneous Society resolved to conduct feasibility studies. The National Academy of Sciences-National Research Council then decided to sponsor a closer check on the area.

Earthquake Waves

Four oceanographic research vessels, representing Columbia University's Lamont Geological Observatory, the Woods Hole Oceanographic Institution, Hudson Laboratories and Texas A.&M. College were recruited and dispatched to an area of approximately three and a half mile deep water 150 miles north of Puerto Rico called the Outer Ridge. To this locale were sent not only survey ships but personnel and all available instruments and equipment for a thorough geophysical investigation of the earth's crust north of the Puerto Rico deep sea trench.

Since our knowledge of the inside of the earth is derived mainly from the measurements made by seismologists on the travel of earthquake waves, seismic soundings were germane to the project; indeed, they were an absolute necessity. At the Moho, where the mantle meets the crust, the velocity of earthquake waves has been found to range from between 15,000 to 20,000 feet per second in the crust to over 25,000 feet per second below.

This phenomenon, discovered by the Yugoslav scientist for whom the Moho is named, has been ascertained through the study of natural and artificial earthquake waves on land and

"EASY, MEN, THAT'S DYNAMITE!" *Scientists from the Lamont Geological Observatory and from Texas A. & M. College load depth charges on board the R. V.* Hidalgo, *one of the expedition's survey ships. The depth charges are used to create sound waves for exploration of the sea floor, and the rock layers beneath it, by seismic methods. (Photo by author)*

at sea. It has also been pointed out that the greater the velocity at which sound waves travel, the denser the material they are going through.

Thus, with seismic records of wave travel times we can learn the depth and thickness of the various sediments and rock layers in the ocean floor, and the depth to the bottom of the earth's crust at the Moho. It was the task of assembling this data in the Puerto Rican deep to which the survey team enthusiastically addressed itself.

Funds From O.N.R.

Much of the funds for the survey and all of the explosives were supplied by the U.S. Office of Naval Research. However, as none of the institutions participating had seismic equipment for reflection surveying, the type used so successfully in previous probes for ocean-bottom oil, outside help was needed. The Department of Oceanography of Texas A.&M. sent out an appeal to the Texas geophysical in-

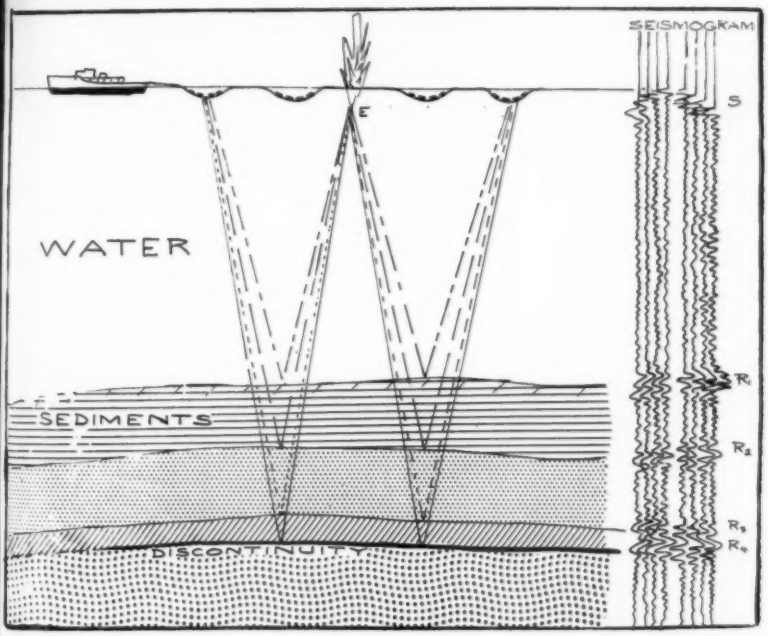
dustry. Offshore Exploration Group loaned the seismic cable, and the necessary electronic instruments were borrowed from the General Geophysical Company.

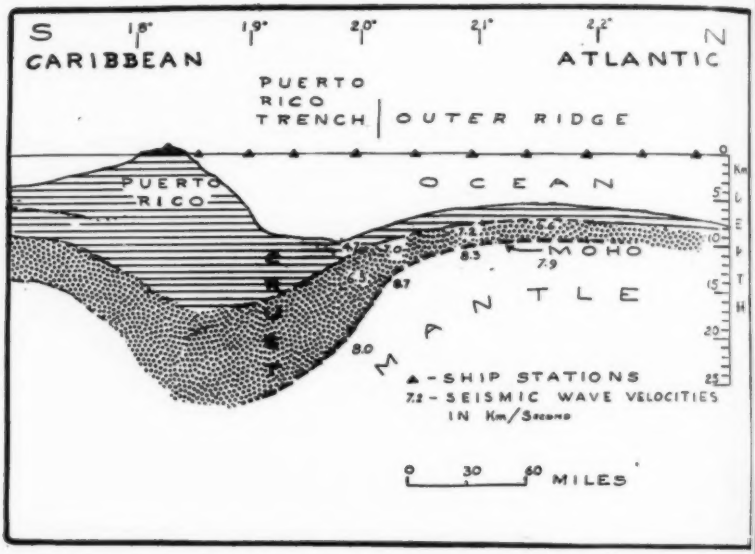
Dr. John E. Nafe of the Lamont Group was elected to direct the project as Chief Scientist. Dr. Nafe was aboard the *Vema,* flagship of the research flotilla. The other ships included the *Gibbs* from Hudson Lab, the *Bear* from Woods Hole and the *Hidalgo* from Texas A.&M. The latter was probably the best equipped vessel in the fleet for the taking of seismic reflection surveys, and it was from her that a great deal of the recording was done.

No Pleasure Cruise!

When the *Hidalgo* left Galveston harbor, she had aboard, in addition to the crew, two seismologists, a Chief Ship Scientist, a Ship's Captain, a meteorologist, an observer from G.E., some Indian geology students, and a

OIL FIELDS ARE ALSO DISCOVERED *this way. In geophysical surveying, to determine rock-layer depths, a 2,000-foot long floating cable is pulled behind the survey ship. Attached to this cable at intervals are groups of hydrophones. These pick up the shock waves produced by an explosion at "E," and returned as echoes from the sea floor and from the rock layers beneath it. Vibrations are recorded on a long strip of photographic paper, echoes being recognized by galvanometer traces on the seismogram being deflected in the same way (right, R1, R2, R3, and R4). The time elapsed between the explosion and the return of each echo is a measure of the depth of the particular rock layer. (Drawing by author)*





IN THIS CROSS SECTION *of the crust of the earth and of the Atlantic Ocean north of Puerto Rico, the crust has considerable thickness beneath the island, but thins out beneath the Outer Ridge, north of the Puerto Rico Trench. The thin area is one of the proposed sites for the drilling of "Mohole" through the earth's crust to the Mohorovicic discontinuity (marked "Moho"), at the edge of the earth's mantle. (Drawn by author)*

couple of assorted oceanographic technicians. From the very start, however, it was not a pleasure cruise. Much of the equipment had been left un-installed upon departure, and the first few days at sea aboard the ex-mine sweeper were sheer toil, with work beginning at 6 a.m. and not ending until shortly before midnight. Hydrophones had to be wired in pairs and attached in series of eight and nine to the floating seismic cable. Throughout the day groups of men sat on the deck wrapping insulating rubber tape around the connecting cables. Ninety-six hydrophones had to be attached to 2,000 feet of cable. It was an onerous task, but this was vital equipment.

We Take To Our Bunks

During the *Hidalgo's* Gulf of Mexico crossing, skies and seas fortunately remained calm. As she put in at Key West to pick up explosives, however, the weather became unpleasant, and on proceeding to San Juan, where she was to rendezvous with other ships of the small flotilla, heavy seas hindered her progress. They also drove both scientists and crew green-faced into their bunks.

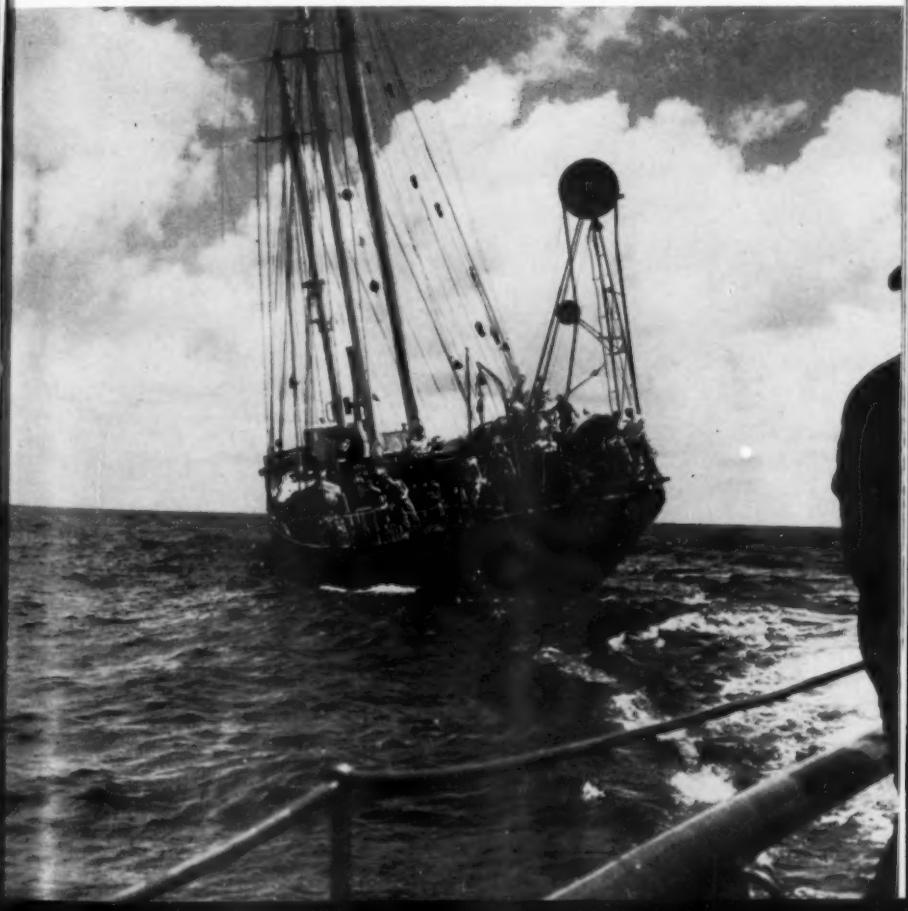
Three days behind schedule, the *Hidalgo* slipped into the harbor of

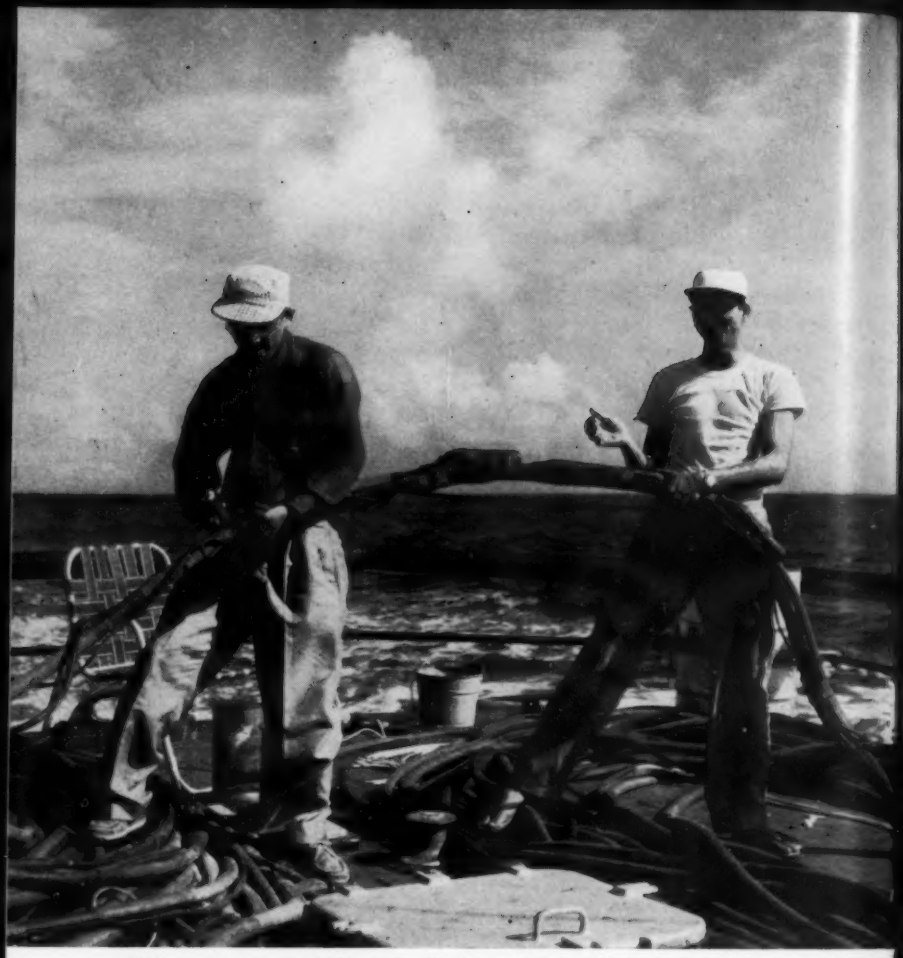
San Juan, with nary another vessel in sight. Within forty - eight hours, however, her scientists and crew, surprised to be the first arrivals because of the bad weather and some equipment troubles, were talking about it to those on board the *Vema* and the *Bear*. They got another surprise: the arrival of two females, both experienced ocean researchers. It is a rare oceanographic survey that carries a woman aboard, much less two. Both the *Hidalgo* and the Moho survey were off to an auspicious, if not historical, start!

More Explosives Loaded

Two days later the three ships arrived at Roosevelt Roads, a U.S. Navy base on the east coast of Puerto Rico, and the fleet was met by its largest member, the *Gibbs*, of Woods Hole.

NO PLACE FOR THE SEASICK, *or for anyone afraid to get his hands wet or dirty. Research Vessel* Vema, *of the Lamont Geological Observatory, Columbia University, hove to on geophysical station, 120 miles north of San Juan, Puerto Rico, as seen from the Research Vessel* Hidalgo. *The odd derrick on the stern of the* Vema *carries a hydraulic drilling rig for sampling the sea bottom. (Photo by author)*





TWO STUDENTS FROM INDIA *lend a hand. During the long sea voyage to the survey area north of Puerto Rico, there was never an idle moment. Here hydrophones are being attached to the long cable which was floated behind the survey ships to pick up shock waves from depth charges. The Indian students, attached to Texas A.&M. College, liked this practical application of their work in geophysics. (Photo by author)*

More explosives, including many 500 pound charges for long distance underwater surveying, were taken on.

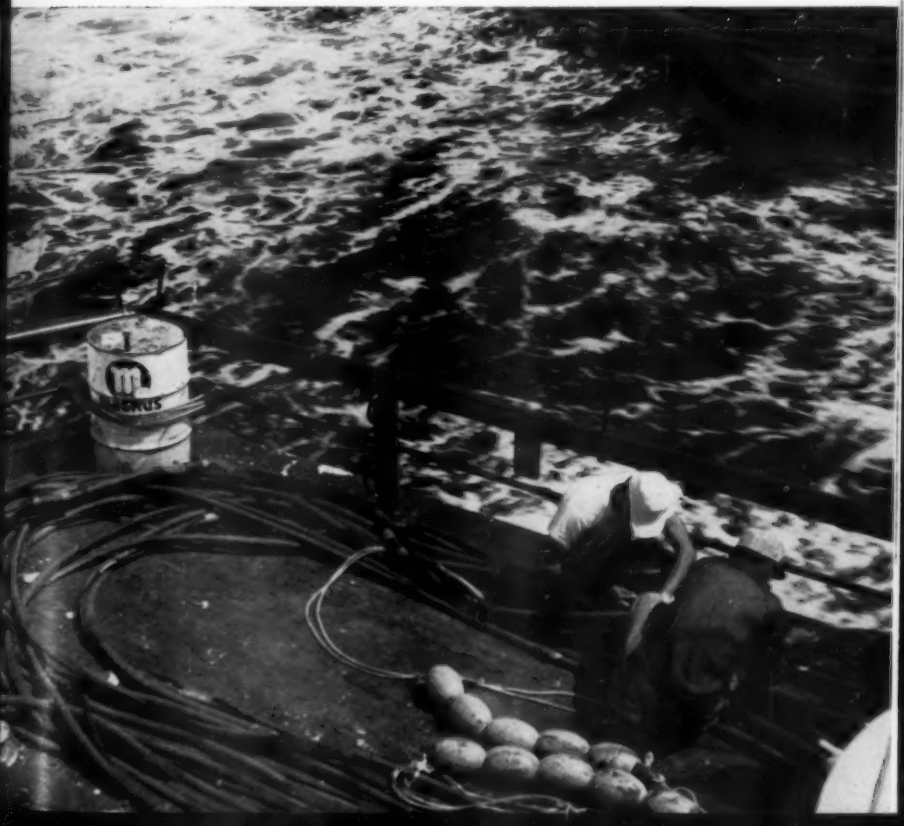
Finally, all members of the team were ready to begin the job of outlining the Moho. Since it was the fastest vessel, the *Hidalgo* steamed far to the North to take up its position as listening ship on the first profile or survey line. As soon as she reached her station, engines were cut and the ship hove to. Lying in the trough of the seas, she pitched, tossed and rolled helplessly, decks slippery as greased ice.

Like most oceanographic vessels,

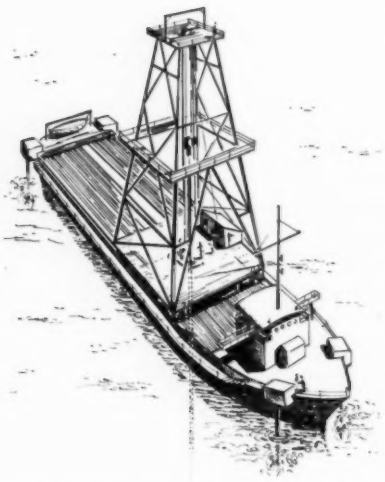
the *Hidalgo* is small and rough riding, with relatively cramped quarters. Heavy gear must be handled day and night in any and all kinds of weather. On this occasion, both personnel and equipment, including a radio that suffered a collision with a stairway, were having a rough time of it.

Finally Project Begins

Finally, the seas calmed, and the *Hidalgo* was ready to go to work. On this run, as on most, the main job was to receive the refracted ground waves transmitted from the shooting ship. The *Gibbs,* waiting to drop her charges, was fifty miles away. After a slight delay, as the other vessels made final adjustments, the *Gibbs* began her run, dropping depth charges at thirty minute intervals. Before each charge exploded, one of the *Gibbs's* scientists announced, through the ship's radio system, that a charge had been dropped, plus its size, fuse length and estimated burning time. As the *Gibbs* approached the *Hidalgo* her charges became smaller, with shorter intervals between their detonation. With more



ANOTHER TEDIOUS JOB *en route to the survey area was the fastening of hydrophones and floats (center) to the reflection seismic cable, loaned to A. & M. College of Texas by the Offshore Exploration Group. Two students rig floats to the hydrophone takeout section of the cable. (Photo by author)*



THE SEARCH FOR OIL *in increasingly deeper waters along the continental shelf has led to the development of* floating *drill platforms, mounting full-size rigs. Similar craft, with four king-size outboard motors to hold it in position, might meet the requirements for the Mohole drilling job. The total reach of the drill would be 18,000 feet. (National Academy of Sciences — National Research Council)*

frequent explosions to record, the *Hidalgo* crew became frantically busy.

Throughout the night scientists pulled in hydrophone cables and let them out again before each shot; student assistants dashed back and forth to the dark room with bags of exposed records and back to the recording units with ribbons of dripping seismograms. These were spread out on a table and examined in dim flashlight by the seismologists, who counted out the timing lines, corrected the explosion time for the depth of the charge in the water at the instant of detonation, and radioed back the computed water and ground wave travel times to the shooting ship.

Nature of Seismic Waves

Refracted seismic waves follow the laws of sound and of optics. Once discharged from an explosion, they are deflected from a straight path whenever they pass obliquely from one medium to another of different density. In traversing the various layers of the ocean crust, those that travel at highest velocity will have passed through the deepest layers, and will be picked up at the surface at the farthest point from the detonation site where equipment has been placed to receive it. Those that pass through shallower layers bounce up nearer the detonation point, and so on.

A refraction survey team, therefore, will consist of several ships, in this case three plus a shooting ship, located from thirty to seventy nautical miles from each other, the distance depending on the water depth and the depth of the geologic layer down to which measurements are desired. These are laid out along the profile of the earth's crust to be sound-wave measured. To avoid all possibility of interference with the underwater sound waves, which will be picked up by the hydrophones on the trailing cables, they are cushioned with floats to avoid any disequilibrium. The refracted wave travel times are then recorded on a seismogram, on which a reflected, a refracted and a direct water wave will be indicated.

After the travel times of the direct water wave and the ground wave have been recorded for the different positions of the shooting ship during its

run, they are plotted on a graph. Straight line segments, joining individual points of ground wave plotted against water time, represent a geological layer having a certain seismic wave velocity and, therefore, a certain geological constitution. The slopes of the same line segments are a measure of the velocity of the artificial earthquake waves in the particular layer. The intersection of the continuation of each line segment with the vertical axis of the graph is a measure of the depth to the particular geologic horizon.

Throughout four days the *Hidalgo* took part in the seismic survey, as the ships took up new positions along the 180 miles of the three refraction profiles. From time to time she would function as a shooting ship, her scientists and crew grimly making up charges, lighting them and tossing them over.

Keeping Clear of Propellers

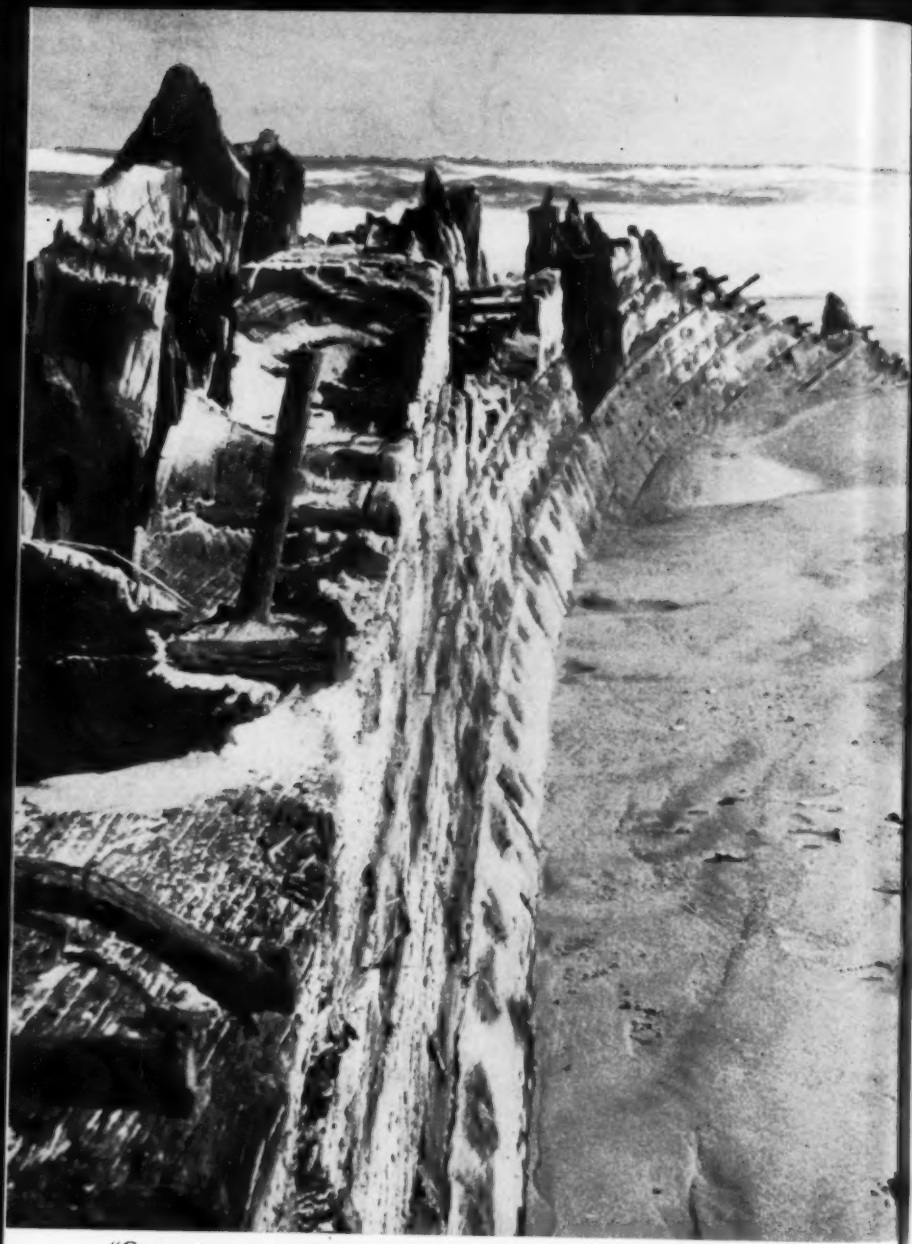
For reflection operations, a long hydrophone cable was streamed behind the ship. Floats were snapped on to support the heavy instrument sections. Pulling the cable back aboard required constant care to keep it from being ground into the churning propellers. In reflection work the charge is attached to a shooting line which also trails behind the ship with a colored plastic bag to mark its position. As soon as the charge is determined to be in the center of the hydrophone cable, 1,000 feet astern of the vessel, the charge is detonated and the echoes reflected from subbottom sediment layers are recorded for all eternity on the seismograph.

No job for the faint of heart, the light of muscle or the weak of stomach, is such ocean research as the Atlantic Moho probe. It calls further for a love of ocean, boats, and one's scientific work. Whether the Mohole is drilled in the Atlantic or the Pacific, where another site has also been surveyed, whether it is completed on schedule or late, whether it will cost the estimated $15 million — all of these will be determined later. Now the collected data must be analyzed, and those who helped collect it can look back on a most rewarding job on one of the most exciting frontiers of 20th Century science.

"*Least Studied Ocean*"

Plans have been completed for a four-year survey of the Indian Ocean, regarded by leading marine scientists as "the ocean that has been the least studied."

Ships from the United States, the Soviet Union, and perhaps several other nations will take part. Oceanographers and marine biologists have a special interest in the Indian Ocean, not only because of the richness of life in parts of its area but also because of the strange tendency of its fish and other living creatures to vanish in one place and then mysteriously erupt in another.



"GRAVEYARD OF THE ATLANTIC" *they call the Cape Hatteras area because so many ships have been lost in its treacherous currents and shoals. Wrecks, such as this one at Nags Head, however, are the delight of both fishermen and photographers. Within such hulks small fishes and other marine life can mature, safe from predators. (North Carolina News Bureau)*

Proposed Hatteras Laboratory

By F. G. WALTON SMITH

MARINE BIOLOGISTS and oceanographers have long been aware that the Cape Hatteras area might be one of the most fruitful places to establish a field station for scientific research.

Not only is Hatteras the meeting place of two distinct faunae, or marine animal groups, but the Outer Banks offer peculiar ecological conditions, both to seaward and soundward, which are worthy of investigation in themselves.

Conference of July 17th

As a preliminary step toward the establishment of such a station, a conference was arranged by Mr. Charles F. Johnson, noted game fisherman, at the Hatteras Marlin Club, Hatteras, North Carolina, July 17. Attending the meeting were Dr. James Morrow, Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut; Dr. William W. Hassler, Department of Zoology, North Carolina State College, Raleigh; Mr. Charles F. Johnson and Mr. E. Lansdell Anderson, of the Marlin Club, and the author, representing The Marine Laboratory, University of Miami, as well as the International Oceanographic Foundation. Mr. Johnson is President of the Marlin Club and also of the International Oceanographic Foundation.

During the discussion at the meeting, Mr. Johnson referred to the statement of Governor Luther Hodges, made at the formal organization meeting of the Club, to the effect that the Club and its members had a great opportunity to encourage conservation and game fish research. Mr. Johnson suggested that a marine biological station might be set up under the auspices of the International Oceanographic Foundation, and that he would undertake to provide land for a laboratory building.

Some interesting statistics were presented to justify the establishment of a research station, giving an indication of the work that might be pursued in the pelagic, or open sea, fishes alone. For instance, sixty blue marlin were boated off Hatteras Island during 1958, and the catches to July in 1959 were considerably greater. In fact, during the brief period between May 9 and July 1, 1959, about 110 blue marlin, weighing up to 459 pounds in size, had been boated between Hatteras and Oregon Inlet. Similarly large catches of white marlin also were reported.

Need Prompt Examination

The importance of these catches to science was emphasized by Drs. Morrow and Hassler, who pointed out that there is no other place on the Atlantic coast of the United States, or even in the neighborhood of the Bahamas, where blue marlins are taken in more than a fraction of the quantity. Facilities for prompt examination of the fish on the spot, at Hatteras,

would be of immense benefit to a number of biologists interested in this relatively unstudied group. A new surmise, requiring more investigation, is that breeding might occur in this area, on the basis of some examinations of ovaries during May and June. Dr. Hassler mentioned some of his own field work here, and his desire to bring students to work in the area.

To an inquiry as to whether there might be a possibility here of duplicating laboratory facilities at Beaufort and Morehead City, the answer was that marlins landed at Morehead City were caught as much as thirty to forty miles from the dock, and that no laboratories existed within easy access of the Outer Banks. Dr. Morrow said that not only himself but a number of other billfish investigators would make full use of a laboratory at Hatteras. It was also apparent that the area is of special and unique interest to marine biologists in many other respects.

Two Possible Sites

It was finally agreed that there was sufficient justification to build and operate a marine station at Hatteras, which would act as a field laboratory for those desirous of studying, while still in good condition, the marlin and other game fish landed there. It would also serve those who wished to study the general marine biology of the area, and provide a collecting center for graduate students.

The committee agreed that the laboratory would be initiated in a modest way and be allowed to grow only as the demands upon it required. It would serve a number of individuals and institutions, both in North Carolina and farther afield, rather than establish its own permanent research program and scientific staff.

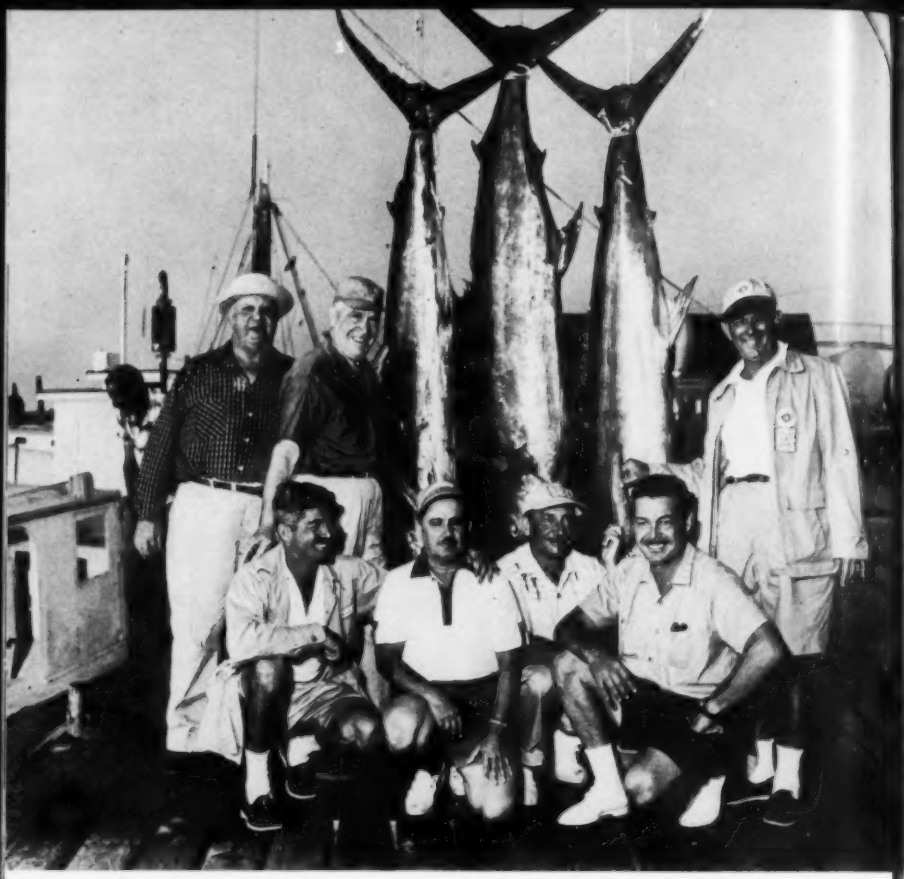
Two possible sites were suggested by Mr. Johnson. One is a strip of land in his possession, some distance back from the Club and dock. The other is on the opposite side of the creek, adjacent to a site which might become the location of a small cannery. Mr. Johnson's offer to donate one or the other of these sites was met with great appreciation. After inspecting these sites, it was agreed that no final decision could be made until plans for the remaining land and for the laboratory itself had become more clearly defined, and the possibility of a cannery had been definitely established.

I.O.F. Sponsorship?

It was further agreed that the International Oceanographic Foundation might be asked to sponsor the proposed laboratory, and to make its facilities available to all qualified persons. The type of building was temporarily left in abeyance, although tentative plans drawn up by Dr. Hassler were examined and considered suitable for the purposes and objectives already outlined.

While it was decided that a full-time paid resident scientist would not be feasible at first, Dr. Hassler stated that he was prepared to assume responsibility for the local administration and operation of the laboratory. It was further pointed out that a laboratory building on property adjacent

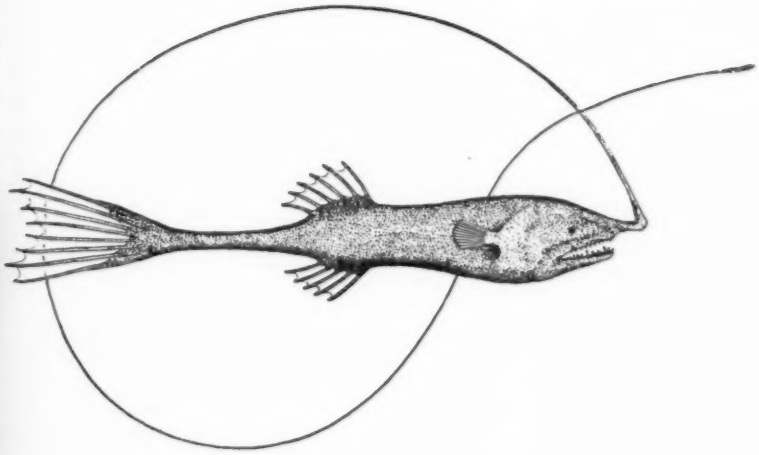
INDIANS FISHED THESE *waters long before the white man came. This is a copy of a De Bry engraving, from a drawing by explorer John White, circa 1590. Note the spears, traps and handnets, and the quite accurate sketches of marine flora and fauna. (Hall of History, North Carolina)*



GAME FISHERMEN *produce real evidence that the Cape Hatteras area is a very good place to catch deep sea fish. Here the Puerto Rico team, international champions, display three sizeable blue marlin. With the group (second from the left, rear row) is North Carolina's Governor, Luther H. Hodges. (State of North Carolina photo)*

to the Club might be under the surveillance of Club employees, and therefore be safer from vandalism, when no scientists were using it. As for living quarters, it was noted that small numbers of visiting scientists and students might be accommodated at the National Park Service buildings.

The International Oceanographic Foundation has now set up a committee, consisting of those present, together with others considered desirable, for the purpose of inquiring further into the proposal. The committee seeks the interest, advice and support of various scientists and institutions who might be able to utilize such a laboratory, and to present definite plans and proposals for its establishment.



CLOSELY RELATED *to the angler of Florida waters is* Gigantactis macronema, *a fellow resident of the deep sea. Its color is jet black. Note the long illicium, or "fishing rod," tipped with a light organ that attracts its prey. (From N. B. Marshall,* Aspects of Deep Sea Biology)

The Rare Angler

WALTER R. COURTENAY, JR.

THE DEEP SEA REALM, even to experienced marine biologists, today still offers the excitement of new discovery. Scientists and fishermen alike anxiously await the arrival on board of some net or gear being towed at great depths, because many of the bizarre forms of life captured from the deep sea have never before been seen by man.

Some of these are the angler-fishes, so-named because of the various "fishing rods" and "lures" they possess. Such "fishing gear" represents a modified first dorsal spine and is one of the structures relating the deep sea angler-fishes to the frogfishes (see "Almost too Ugly for Words" by E. John Long, *Sea Frontiers,* Volume 4, Number 1). One of the rarest of this type of deep water fish was found during recent years, in Florida waters.

Live At Great Depths

These fishes are generally found living at a depth of 1700 meters (approximately 3,400 fathoms), where

constant darkness and extremely cold water are the unvarying conditions. This great depth, with its scarcity of life, has prevented scientists from capturing numerous specimens. Therefore, our knowledge of this group is very limited.

Occasionally deep sea anglers have been found in the stomachs of whales, but most have been captured in deep water nets. These fishes, for the most part, are probably sluggish swimmers, but some appear to be physically capable of avoiding capture in nets and trawls. It is for this reason that they are rarely caught.

Males and Females Different

Deep sea anglers show an amazing structural difference between males and females. Females possess a bony spine or illicium at the end of the snout which has, at its tip, a bulb-shaped organ, often called a "bait," which is both a sensory structure and a light-producing organ.

The male anglers have no illicium, produce no light, and are much smaller than females. In certain species of angler-fishes, in fact, the males attach themselves to the side of a female with their teeth during the breeding season, and in other species the males become fused to the body of the female and lead a parasitic existence. They are practically permanent and helpless appendages to the females.

Attract Prey by Light

By dangling the illicium in front of the angler's mouth and lighting the "bait," the female attracts her prey. Because her eyes are not sufficiently developed for vision, the sensory structures on the "bait" act as antennae and signal her when food is under the light. The jaws of the fish then open and the prey is engulfed in an instant. Hence the name "angler-fish."

The eyes of the males, however, are generally much more developed and are probably used for feeding on luminescent organisms and in recognizing the flashing "bait" of the female during the breeding season.

The actual working mechanism of the light organ is not known, but it is believed that the light is produced by luminescent bacteria contained in great numbers within the "bait." Since it is known that oxygen is required to cause luminescent bacteria to give off light, it is thought that the angler-fish turns the light "off" and "on" by closing and opening blood passages which supply oxygen to the "bait."

"Streamlined" Angler-Fish

Extremely rare among the angler-fishes is the genus *Gigantactis*. These fishes have a jet-black body and are the most streamlined of the group. The illicium is very long and whip-like, much longer than those of other angler-fishes. Most anglers have a short illicium which attracts prey very close to the mouth, and the sudden opening of the jaws with the inrush of water sweeps the prey inside.

The long illicium in *Gigantactis* would require that the "bait" be held far in front of the fish in feeding. Therefore, a streamlined body capable of rapid movement is necessary to catch prey.

In February, 1957, while trawling at night for royal red shrimp in 210

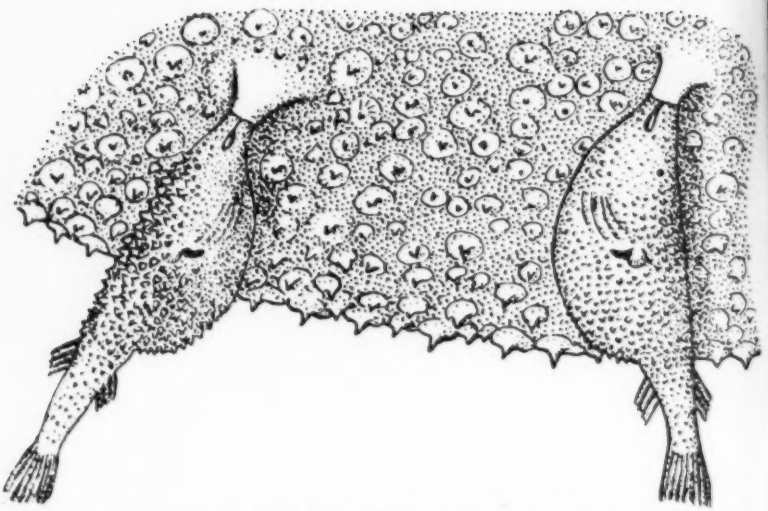
CLOSE-UP OF THE RARE *angler fish caught off New Smyrna, Florida, recently. The dangling tooth at the anterior edge of the lower jaw is broken, and not in normal position. This specimen was 13 inches long, three times the length of the largest specimen previously known in related species. (Photo by author)*

fathoms of water off New Smyrna, Florida, the vessel *Gulf Master* hauled aboard a specimen of *Gigantactis*. This fish, a female, is the largest of its kind ever taken. Mr. Al Pflueger, Miami taxidermist, and a trustee of the International Oceanographic Foundation, notified The Marine Laboratory, University of Miami, that the fish had been sent to him for mounting and would be available for examination.

After studying the specimen carefully and comparing the information gathered with previously known records of this group, it was concluded that this fish represented a new species. The illicium was broken during its capture and its tip, with the "bait," was lost. Therefore, the true length of this whiplike projection and the structure of the "bait" could not be determined. Because the specimen was mounted and not made available for preservation and deposition in a museum for future reference and further study, no scientific name was given to the fish.

Broke All Previous Records

This fish had a length over three times that of the largest specimen previously known. It came from one of the shallower depths at which anglerfishes have been captured. It is also the first record of an adult specimen



TWO TINY MALE ANGLERS *cling to the body of a large female, which they have parasitized. In a few species of these odd Ceratioid fishes, the males are practically permanent and helpless appendages to the females. (From N. B. Marshall,* Aspects of Deep Sea Biology)

of *Gigantactis* from the waters off Florida. It is so rare that another specimen may not be seen for a century or more.

Oldest Multi-celled Animal?

What may be earth's oldest kind of multi-celled animal has been added to the biological collections of the Smithsonian Institution. The specimen represents the second known species of *Neopilina,* living representative of a group supposedly extinct for three million years. A bottom dweller at the greatest depths of the seas, it probably is close to the common ancestral line of mollusks, which ranges from microscopic snails to the giant octopus, and is one of the major groups of animals.

The Smithsonian's specimen is one of four dredged from the Milne-Edwards Trench in the Pacific off Peru at a depth of about 18,000 feet by the *Vema,* research ship of the Lamont Geological Observatory of Columbia University, which institution donated it to the Smithsonian.

THE LAST OF A SPECIES? *In 1909 the New York Zoological Society received three live West Indian seals, which were placed on exhibition in the Bronx Zoo. But all of them died in only a few years. This is one of the three, photographed in its cage. The last ones captured alive, according to the best established reports, were six brought in to Pensacola in 1915. They were caught in the nets of the fishing vessel* Seminole, *whose crew released them in the Florida port. (New York Zoological Society)*

Is The West Indian Seal Extinct?

By RAYMOND M. GILMORE
Research Curator of Marine Mammals, San Diego Natural History Museum

THE WEST INDIAN seal is now considered by many authorities to be extinct. Yet there is a possibility that the creature, once abundant in the Caribbean and the Gulf of Mexico, may still exist!

From lighthouse keepers, shrimp boat captains, aviators, yachtsmen and others have come scattered reports of sightings in recent years. Of course, these are casual observations, most of them made by non-zoologists at times when they were not actually looking for seals.

They may even have mistaken porpoises, or blackfish, or other sea creatures for seals.

Worth Investigating

But where there is so much smoke there is often fire. To the scientist, the marine biologist in this instance, any clue should be followed up to determine whether a once-living thing, now regarded as extinct, may still be alive. That this is no idle notion or pastime was amply demonstrated in 1938, when Dr. J. L. B. Smith investigated and identified, off the East African

coast, a coelacanth, a group of primitive fishes thought to have disappeared from the world about 50,000,000 years ago.

It may come as a surprise to many who consider seals only as cold-water dwellers that such furry creatures can thrive in warm tropical waters. Actually the West Indian seal is only one of three species of the genus *Monachus,* meaning monk seal, that inhabit tropical waters to the exclusion of polar seas. The same thick layers of blubber that insulate their northern cousins against loss of body heat, protect "the monks" from the fierce heat of the tropical sun.

More About the Seal Itself

The three "species" of tropical seals are: *Monachus monachus,* the Mediterranean seal; *Monachus tropicalis,* the West Indian seal; and *Monachus schauinslandi,* the Hawaiian seal. These three occupy a belt around the tropical oceans from the Black Sea through the Mediterranean to the Canary Islands; then, through the West Indies; and, finally, through the Hawaiian group. There are thus two big ocean gaps in the belt.

What Zoologists Want to Know

What interests zoologists is not only how a seal became tropical, i.e. what it took on new in structure and behavior, and what it lost by disuse, but also something of the past history of tropical seals, to explain their present broken distribution into three isolated population centers.

Once, obviously, all these populations were in contact, simultaneously or in succession. The slight differences evident mean that the contacts probably were not very long ago, geologically speaking. If one knew exactly when the Hawaiian and the West Indian populations were in touch with each other across the Panamanian region, he could say something about the rate at which evolution has brought about differences in anatomy.

Judith King's Conclusions

On the basis of one specimen of the Hawaiian seal, three of the West Indian seal, and twelve of the Mediterranean seal, Judith King, of the British Museum, concluded that the Hawaiian species and the West Indian seal are more closely related, and thus more recently connected physically, than the West Indian seal and the Mediterranean seal.

Yet, it would seem more likely for the two latter species to have been in continual, sporadic contact, even today, granting that West Indian survivors exist. The Mediterranean seals perhaps could reach the West Indies on the westward flowing Canaries Current. On the other hand, the dry land of the Isthmus of Panama, and the whole of Central America stand between the West Indian seals and their Hawaiian cousins, as they have since the late Pliocene era, some two or three million years ago.

Overland Travellers?

But Judith King has an explanation for this in her monograph on monk seals *(Bulletin of the British Museum of Natural History,* Vol. 3, No. 5, 1956): "When it is accepted that Phocids are capable of considerable overland journeys" . . . and "If rivers

were exploited . . . in the narrow isthmus of Panama (50 miles wide and 200 feet above sea level) the distances traveled overland might have been still further diminished. The North Equatorial Current of the Pacific could well have borne the animals from the West Indies to the island they now occupy."

Other students believe that the last contact between the Hawaiian and West Indian populations took place before land rose in Central America in the geological time known as mid-Pliocene.

Met Columbus and Ponce de Leon

When Columbus and Ponce de Leon came to the New World, among the first to greet their caravels, according to their own reports, were herds of West Indian seals. This seal then ranged from the Leeward and Windward Islands through the West Indies, particularly along the coasts of the large islands of Hispaniola, Jamaica and Cuba to the Bahamas, southern Florida, the Gulf of Campeche, and perhaps as far south as Venezuela.

In fact, until nearly the beginning of the 20th Century, the West Indian seal supplied the inhabitants of a vast area with valuable hides, meat and fat, as well as oil. But no one gave any thought to the seal's future, so the helpless creature was slaughtered in great numbers until — today, where can it be found?

HAWAIIAN COUSIN OF THE *West Indian seal. Once the three types of tropical seals—Mediterranean, West Indian and Hawaiian — were in touch with each other, possibly before land rose in Central America in the geological time known as mid-Pliocene. One authority believes seals may have migrated overland even later, using rivers or streams for most of the distance. This Hawaiian seal was photographed on French Frigate Shoals in the Pacific. (U. S. Fish and Wildlife Service)*

SEARCH PARTY AND RESIDENTS *of Carmen, Mexican port from which the aerial reconnaissance began. Front row, Frank J. Mather, III, Woods Hole Oceanographic Institution, and two of the expedition's local well wishers. Rear row (left) the author and Col. John K. Howard, Trustee of the I.O.F. (Photo from the author)*

Perhaps in some half-hidden cove along a jungle coast, or on a lonely off-shore islet, or along a partly-submerged coral reef, one might still chance upon the remnants of a herd or two, clinging to life and awaiting the protection of man, who has much better views about the preservation of rare living things today.

Back in 1950, Colonel John K. Howard and I thought we knew a promising area for such survivors. On the strength of reports reaching us from various sources, we decided to search the cayos, or keys, of the Gulf of Campeche off the coast of Mexico. We were led to believe also that there might be individual seals or very small herds in such out-of-the-way spots as Pedro Keys, south of Jamaica; the Serranilla Keys in the Caribbean, or on some of the lonely islets off Costa Rica and Honduras.

Genesis of the Search

We decided to concentrate our efforts on the waters bordering on or near the Yucatan peninsula of Mexico. This search of ours started, like all such end-points of effort, with a chain of events leading far back to a project of the American Committee for the International Protection of Nature. One of its aims was to secure the most recent and reliable information on extinct and vanishing mammals of the Western Hemisphere.

Harold J. Coolidge, Jr., Secretary of the Committee, and researcher Dr. Glover M. Allen, from Committee Headquarters in the Museum of Comparative Zoology at Harvard University, enlisted the aid of Colonel John K. Howard, of Boston. Howard, now a member of the Board of Trustees of the International Oceanographic Foundation, was interested in the West Indies as a locale of big game fishing, and likewise was a good friend of the Museum. He welcomed the chance to investigate the status of the West Indian seal.

Four Seals Sighted!

This was just prior to World War II. Various circumstances prevented any personal participation of Colonel Howard in a search for the beast until 1950. Interest in the project was revived by a letter from Dr. B. F. Osorio-Tafall, Mexican representative of the Food and Agricultural Organization of the United Nations. Dr. Osorio-Tafall advised Mr. Coolidge that Hernandez Ramos, chief lighthouse inspector from Vera Cruz, had sighted, in June, 1948, four seals on the beach of West Triangle Key, far out in the Gulf of Campeche. So we set out for Carmen, Campeche.

We immediately began work on two things: (1) Find out all we could from informants anywhere, and particularly from those who might know of the animal through their local activities, and (2) get transportation to the outlying coral keys, or cayos, to search for the animal ourselves.

Running Down Clues

As I spoke Spanish, the leg-work fell on me. In my quest of clues, in bar, wharf, boat, restaurant and hotel, as well as private homes in Carmen and also in Progreso, the port of Mérida, I picked up some information as well as misinformation. Old timers knew of the seal, and where it was once abundant, but could give me

WATERFRONT AT CARMEN, *famous Mexican shrimping port. In this photograph the shrimp fleet is in, but when the author first tried to hitchhike a ride on one of them, all the boats were out. Shrimp boat crews and captains did not have much information of value in the search for the West Indian seal. (Photo from the author)*

ARE THESE WATERS THE LAST REFUGE *of the West Indian seal? Dashes indicate the course followed by the author's plane as he scanned seldom visited cayos or atolls along the edge of the 100-fathom line (dotted) in the Gulf of Campeche. (Map by Rosemary Latimore)*

little of value for current localization of the search.

Also we learned that no boats were available. They were out shrimping, the prices for shrimp being very high on the American market. Even C-51's were flying regularly in and out for shrimp. Beside this, the "northers," or cold stiff winds from the plains of Texas and farther north, were blowing, making for hazardous operations by boat at the cayos.

We Get a Break

But then a break happened, as is the case so often when perseverance keeps on eliminating failures. A patrol plane of the Mexican Navy, used to scout for poaching shrimpers and "snappers," came in to make a detailed flight over the Campeche banks, bordering the Gulf of Mexico. Telephone calls and telegrams to Mexico City brought official permission to join the flight.

Early on the morning of March 5 we boarded the plane, a beaten-up PBY, piloted magnificently, as it turned out, by the Teniente de Navio P. A. Bernardo Padilla. Along with seven other Mexican personnel (one a man with his wife and baby), bound for the Mexican Navy base at Cozumel Island on the east side of the Yucatan Peninsula, we were on our way to look for seals.

Cayos Arcas, Far from Shore

Within an hour the plane was over Cayos Arcas, 100 miles north of Carmen, and eleven miles inside the edge of the great banks, which here are sharply marked off and easily distinguished from the deep basin of the Gulf of Mexico by the contrast between brown or green water, and deep blue water falling off from the 30-fathom contour. It is this whole bank, in some places 100 miles from shore, and for nine miles beyond the bank, that Mexico claims as territorial waters. In this vast shallow area, American boats seeking shrimp and snapper are considered "poachers."

Data from many informants gave the Arcas as a former hauling place of the West Indian seal, so down we spiralled to 250 feet or so to have a close look. The Cayos Arcas has three parts: East Cay, of coral and barely awash at low tide; Middle Cay, mostly of sand, but with an extensive reef, and bearing the lighthouse; and West Cay, of coral and entirely awash. The low sweep of our plane over the triangular set of cayos disclosed no seals, but birds and driftwood were easily visible, as well as the beautiful coral reefs beneath the surface. So off we soared to the next group, the Triángulos, the most famous site of former sealing activities.

"Dragging" the East Cay

We covered the fifty miles north in half an hour, and again saw below us that indescribable spectacle of a coral atoll and reef, alone in a vast blue tropical sea. East Triángulo is a solid reef, with some sand and a small pond of water. Six miles away lay West Triángulo, with the lighthouse for the group. We "dragged" the east cay, but saw nothing like a seal.

Thinking that the lighthouse keeper on West Triángulo might have current and valuable information for us, I asked the pilot if he planned to land in the small cove south of the lighthouse, and, if so, I would talk with the keeper. Without a word, except "Si, señor," he went in for a try.

Almost a Disaster!

The surface did not look so rough until we were within 100 feet or less of it; and then the waves appeared to become bigger and bigger—so big, in fact, that when we hit we bounced a good ten feet in the air, and then ploughed through the next swell, with green water over the entire hull. Gallons poured in through the old uncalked hatches onto us, onto the crew, the maps, etc. It looked like the jig was up.

Strangely, no one moved out of his seat, except me. I wheeled around, grabbed a Mae West jacket, and put it on, ready to go out through the hatch. The others sat calmly and fatalistically.

Some Difficult Piloting

That is, all except the pilot, who pulled both throttles back to full. The motors, which were on the overhead wing and unimmersed, caught the fresh flood of gasoline with a thunderous roar, and started to haul us back up from the watery world into one of air, thin and invisible, but oh so safe! With a final series of shuddering bumps on the wave tops, the good old faithful PBY was air-borne, and again we were on our way, with the nose set for Cayos Arenas.

Ninety miles northeast and another hour, and we were there, circling and looking again—this time not so low, as time was running short. No seals were seen, but again we were rewarded with a lovely coral atoll, a single long curving arc of reef and sand, in one symmetrical body, open to the west *away* from the prevailing trade winds, and curved toward the northeast *toward* those same winds—a truly stunning sight.

Closed Atoll of Alacran

Finally 100 miles farther east and north came the culminating view of all—the enormous oblong, closed atoll of Arrecife Alacrán, fifteen miles in diameter north and south, and ten miles east and west. Beneath us lay a truly magnificent panorama of wave-splashed reef and sandy beaches, mottled shallows of coral, interlaced with a spiderweb of channels. At the southern extremity the land rose a little, and we could see a palm-shaded shack or two, and an erect white lighthouse.

This southern tip, called Isla Pérez, is habitable, but no boats were there, nor any sign of life. Yet the lighthouse keeper was no doubt nearby. From time to time, I had been told, atoll and reefs are visited by Cuban lobstermen.

Most Likely Habitat

Here we thought surely there would be seals, because how could such a vast and ideal habitat, almost inaccessible to man over much of its network of parts, be other than the last stronghold of the species, his last inviolable refuge and home?

Yet, although we circled over the southern half of the great Arrecife Alacrán, or "Scorpion Reef," and raised thousands of sea birds, like a blizzard coming up instead of down, we saw no seals. This does not mean that none may be there. Our altitude was a bit high for real observation and we did not fly over the northern half.

So, while results of our aerial reconnaissance of the banks area were negative as far as the actual sighting of seals were concerned, I think we located some likely spots that might be given closer scrutiny from a cabin cruiser, in the hands of a skilled helmsman. In my opinion, Alacrán looks like the best place to find the missing seal, and certainly no more challenging waters could be found near the United States for adventurous boating as well as fishing, swimming and general exploration of a spot seldom visited by travellers.

We eventually put down at the airport of San Miguel, Cozumel Island, which faces the relatively unknown Mexican coast of Quintana Roo

MERE DOTS IN A VAST SHEET OF BLUE SEA. *The reefs and lagoons of Cayos Arcas were the first to be explored during the aerial search for West Indian seals. The pilot flew low enough to enable the members of the party to see birds and driftwood, but no seals were observed. (Raymond M. Gilmore)*

across a channel of ten miles. It was not without relief that we heard the wheels of the amphibious plane move into place, and lock as we came in for our landing. After the pounding on water at West Triángulos Cay, we were not at all sure that the landing gear would work.

Back to Progresso

At San Miguel most of the party disembarked to take up their new post-assignments. After beer and raw conch soaked in lemon juice, we took off again to fly west to Mérida, the capital of Yucatan, where we arrived late in the afternoon. It had been a memorable day, packed with action and thrills.

From Mérida, a city of windmills which pull up water from the limestone just below the surface, I went to Progreso, the new port of Mérida, to gather more information about the seal. The supply ship to the lighthouses of the entire Campeche Gulf and east side of the Yucatan Peninsula is based here. I hoped its crew might have some leads, but no, they didn't. The business of carrying supplies and personnel back and forth every two months does not allow much time for exploration of the reefs.

Collect Fish Specimens

The Progreso visit finished the intensive part of our search for the West Indian seal, although we obtained some additional bits of information during the next week or so that we remained in Carmen, fishing for the collections of Harvard College and the U. S. National Museum. Tarpon, amberjacks, barracuda, sierra and snook came in readily on the reels, testing our lines and skill as fishermen. We stood knee and thigh deep in a tidal channel at the edge of the huge Laguna de Terminos, behind Isla Carmen, and cast into the riffles for tarpon, like casting for trout or salmon in a northern stream!

What were the definite findings of our aerial search? (1) We learned that on the day of the flight, March 5, 1950, on a flooding tide, no seals were hauled out on the cayos of Arcas, Triángulos, Arenas, or around Isla Pérez on the large Alacrán; (2) We also were told that the most recent

reports of seals in the area were those of Ramos and a captain in the Naval Academy, Molina Tuero, both concerning sightings on the Triángulos Keys, one for 1948 and the other for 1949 respectively; (3) however, we had rather positive assurances from a number of informants, including two old seal hunters, some lighthouse keepers, and fishermen, that seals have been seen on *all* the cayos of the Gulf of Campeche in the decades of 1920 and 1930, and possibly even of 1940.

Best Time and Places

Other opinions: (1) The best time to find seals would probably be from December through February, when breeding activities are supposed to be at their height; (2) The Alacrán reef was the most alluring place we saw to explore for seals, to fish, and to have adventure; and next came the area of Cozumel and its channel, plus the opposite coast of Quintana Roo; (3) Finally, we felt certain that the Campeche and Yucatan coastal areas were vast enough to harbor relic survivors of the former seal herds, and that some day, with luck and protection, they would be found there, possibly in increasing numbers.

Serranilla Banks, between Jamaica and Nicaragua, might be another rewarding place. Fishermen formerly stopped and killed seals there, as reported by Bernard Lewis, in 1948, in the Jamaica *Natural History Society Magazine,* Vol. 3, No. 34.

Other Scattered Reports

On the remote Rosalind Banks, southwest of Jamaica, several were reported seen in 1948 by Stewart Springer, former explorer for Shark Industries, and now with the U. S. Fish and Wildlife Service. Mr. Springer also told me that a Mr. B. W. Winkler, of Evansville, Indiana, saw some seals on Old Providence Island, east of Nicaragua, in 1948.

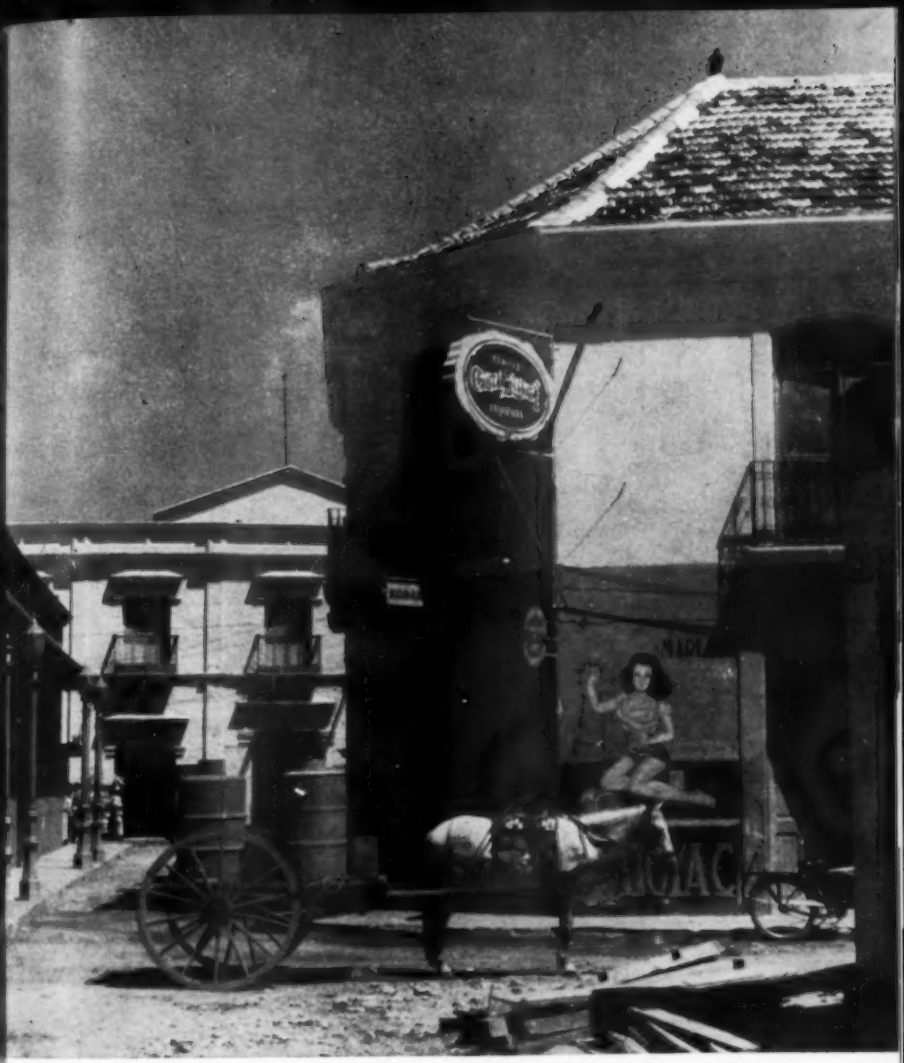
The record would not be complete without some mention of Gordon Gunter's article in the *Journal of Mammalogy* for 1947. He includes reports of observers who claim to have sighted seals near Galveston, and also near Brownsville, Texas, in 1932.

The last ones captured alive, it is believed, were six brought to Pensacola and released there in 1915. They were taken by the crew of the fishing vessel *Seminole,* which evidently obtained them at one of the cayos of the Gulf of Campeche while fishing for red snapper. The famous naturalist, Charles H. Townsend, reported one killed at Key West, Florida, on March 15, 1922, and identified by the aquarist L. L. Mowbray.

Barking Seals of Rocky Cay

Since our trip of 1950, I have received three additional bits of information that should be listed for those who may wish to continue the search by air or by sea. On May 23, 1950, Mr. Bernard C. Lewis, of the Provincial Museum, Kingston, Jamaica, wrote me that a fishing captain had recently heard seals barking at Rocky Cay, formerly Seal Cay, off the south coast. This islet was a member of the Pedro Cays, and formerly had many seals.

In 1950, too, Dr. Henry Setzer, As-



CARMEN, MEXICAN PORT *at the southern end of the Gulf of Campeche, was chosen as the starting place for the seal hunt because a lighthouse inspector said he had sighted four of the animals on the beach of West Triangle Key (Cayos Triangulos) in June, 1948. The author spent much time visiting hotel, restaurants, bars and even private homes in quest of clues. (Raymond M. Gilmore)*

sociate Curator of Mammals of the U. S. National Museum, told me that in April, 1949, he had seen three seals in the channel between Puerto Limón and a small near-shore island in Costa Rica. This is the only record I have of a sighting in Costa Rica.

Pro and Con Reports

The most spectacular report was that obtained by Stewart Springer, of

the U. S. Fish and Wildlife Service, from Dayton Vesper, who was a cook on a tug that, on July 20, 1952, passed througn a herd of about 300 seals swimming in the water, at a distance of about 300 to 600 yards from the ship. Credence is added to the report because the captain of the vessel was acquainted with seals from duty on the west coast. Could these have been a nucleus of remaining West Indian seals, roaming the Gulf of Mexico in the off-breeding season—or were they porpoises?

To prevent such reports from making the prospect of finding seals too alluring and easy, I think I had better conclude with two which give the other side of the coin: (1) A careful scrutiny through binoculars from fairly close range, made by Dr. Loren Woods of the Chicago Museum of Natural History at Cayos Arcas, Triángulos and Arenas in November 1951, disclosed no seals. (2) Likewise a visit to East Triángulos by Harvey Bullis, of the *Oregon* in August, 1951, revealed no living seals—only an old seal skull and a few bones! But perhaps the time of year was not propitious.

Hope For Good News

Should the next news on the West Indian seal be *confirmed good news*, it will mean that the West Indies will again have a conspicuous native animal to make it a more interesting place in which to live and to visit. It is always saddening to hear of a harmless, large and valuable creature being exterminated by man. Such represents a throwback to primitive culture. Civilized man does not abuse and violate his natural surroundings so, and, given a second chance with the West Indian seal, it is safe to assume that this unusual creature will be encouraged to fulfill again its natural role in the scheme of West Indian marine life.

Record Catch by Canadian Whalers

One of the lesser known whaling grounds lies off the west coast of Vancouver Island, British Columbia. Yet whaling is good there. A fleet of six whale-catchers of the British Columbia Packers, Ltd., report a total of 834 whales taken in these waters during the 1959 season, which ended in September. This compares with a total of 774 last year.

However, the whales, including blues, sperm and finback, were smaller, so the total tonnage will be lower than in 1958.

WITHIN LIMITED AREAS *tornadoes can be more destructive than hurricanes, chiefly because tornadoes strike within minutes, whereas modern warning systems give ample notice of the approach of hurricanes, allowing time to "batten down the hatches." This house in Miami, near Biscayne Bay, was left a shambles by the torando of June 17, 1959. (Ronald Nelson)*

Spying on a Tornado

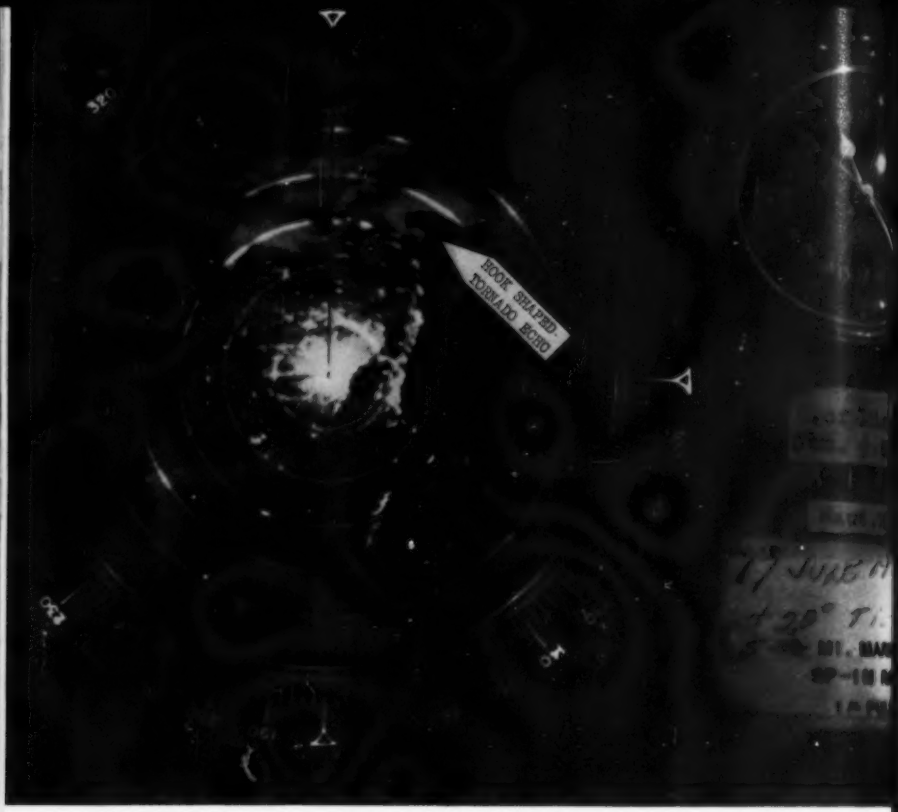
By HOMER W. HISER
Marine Laboratory, University of Miami

NOT OFTEN do scientists have a chance to observe a tornado first hand, particularly at night. Because severe tornadoes are largely inhabitants of the great plains and central portions of the United States, it is even rarer when a marine laboratory in the subtropics has a chance to do the observing with radar meteorological equipment. It is likewise remarkable when a tornado originates over and cuts a path of destruction through a major city and then streaks off to die.

Lightning Outlines Funnel

All these unusual factors were combined to give the city of Miami one of its most violent and destructive tornadoes on record, during the night of June 17, 1959.

I was fortunate to observe it both



A TORNADO'S SELF PORTRAIT. *A peculiar hook-shaped echo shows up clearly on the radar screen of the Meteorological Laboratory of the University of Miami. This is the twister that roared across the city of Miami on the night of June 17, 1959. Adjacent solid-appearing echoes are from local surface targets, such as buildings and islands near the radar antenna. The circles indicate five miles. (Marine Laboratory, University of Miami)*

visually and by radar. I was in my office in the fifth floor of the Merrick Building, on the University of Miami's main campus, when the lights began to fail about 10:00 p.m. I looked out of the windows and saw the tornado funnel clearly backlighted by almost continuous lightning flashes. It was about one mile east of the Radar Meteorological Laboratory, where I was working at the time, and over the Coconut Grove section of Miami.

Turning off the room lights, I watched the twisting black funnel cloud for about five minutes, in order to determine whether to take cover in a more secure portion of the building, or to proceed to the seventh floor and turn on the radars. I decided to chance the latter.

Blue-Green Flashes at Base

I have observed other tornado funnels over rural areas during daylight hours, but this was the most spectacular weather phenomenon I have ever

seen. While the funnel was over the Coconut Grove area, its lower extremity was illuminated by a blue-green light flashing, like an electric welding torch.

However, it would be impossible to say whether or not this was a natural light or was produced by the storm continuously disrupting the network of power lines and circuit breakers in this populated area. I do know that the thunderstorm which accompanied the funnel had an extreme amount of electrical activity, with almost continuous cloud-to-cloud, and cloud-to-ground lightning strokes while it was near the University.

Funnel Not Smooth

It was difficult to see the overall structure of the thunderstorm cloud, but the funnel was well developed and quite dense. The cloud base was fairly low and the funnel extended to the ground. The outer wall of the funnel appeared not to be smooth, but rather was lightly shrouded with wisps of rapidly-changing clouds of the fracto-stratus type.

Although several heavy outbursts of rain fell around the University campus before I observed the tornado, there was only light to moderate shower activity while it was passing nearby.

A Look at the Tornado by Radar

As soon as I determined that the funnel was proceeding in a general northerly direction, I turned on the radars at 10:10 p.m., and began photographing the image on the scopes by about 10:12 p.m. The pictures obtained show a rather well-developed hook-shaped echo, curved counter-clockwise. By this time the tornado was north of the downtown business district, pursuing a generally north-northeasterly course in the direction of the 79th Street Causeway, north of which it roared out to sea. There have been a number of radar observations of tornadoes in other parts of the United States during recent years which have also shown this hook-shaped echo.

I was extremely busy operating two radars in an attempt to collect as much data as possible. However, between 10:12 p.m. and 10:25 p.m., I did manage to steal a few glances out of the window, and could still clearly see the funnel cloud, backlighted by

ON THE RADAR SCOPE, *a hurricane presents quite a different picture. This is "Hurricane Connie" as seen at Hatteras, N. C., during the morning of August 12, 1955. Note the spiral, lower left. The circles are twenty miles apart. (U. S. Weather Bureau)*

lightning flashes, as it moved through the northeastern portions of the city of Miami, ten to fifteen miles away.

How do Tornadoes Form?

Just what are the forces that nature brings together to produce such sudden and violent storms? How does a tornado differ from a hurricane? These are two questions that have been asked frequently since Miami's June 17th twister, which caused property damage estimated in the millions, injured nearly 100 persons, left 1,000 persons homeless, but miraculously cost no lives.

In the middlewest and plains States, tornadoes usually form in regions where cold dry air, in an atmospheric layer between 5,000 and 15,000 feet, flows over a moist layer of air occupying the lower 3,000 to 5,000 feet above the earth's surface. Winds generally increase with altitude, and there is usually a narrow wind stream in the dry air aloft that has about a 30-knot cross wind component, acting at right angles to the winds in low-level warm moist air.

Highly Unstable Condition

This is a highly unstable condition, in which a trough of low pressure, or some other type of convergence, can act as a triggering mechanism to touch off that severe overturning of the atmosphere which may result in a tornado. Western tornadoes often spring from or are associated with severe thunderstorms.

Tornadoes along the Gulf Coast and in the Florida region, on the other hand, frequently form in an equatorial-type airmass, which is moist to great heights. The air may be highly unstable, but it does not have a dry or cool layer aloft. Research shows that the moisture content is very high, relative humidity being over 65 per cent in practically all cases to above 20,000 feet.

In these southern areas the winds normally decrease, instead of increase, with height, and there is no requirement for strong winds at any level, although sharp changes of wind direction with height may be found. Normally, in this type of airmass, only one of the many thunderstorms in a given situation will produce a small tornado or waterspout. These usually occur during daylight hours, and have brief lives.

More Research Needed

The Miami tornado of June 17, 1959 (tornadoes are not given individual names by the Weather Bureau, as are hurricanes) was unique in that it was far more intense and had a much longer life than the usual Florida type, and it occurred late at night. A considerable amount of additional research will be necessary in order to find out how and why this tornado was so different from most that occur in Florida.

As for the difference between tornadoes and hurricanes, we might start with a point of similarity (aside from their destructiveness) — each has winds that rotate (in the northern hemisphere) in a counter-clockwise direction. A hurricane is always born at sea, may last as long as two weeks, and may have a diameter of 200 to 500 miles. Although a hurricane and

ANOTHER HOUSE CASUALTY *of Miami's "sneak tornado" of June 17, 1959. Roofing was ripped off, windows blown out, and walls were carried away. Scientists are seeking the causes of these violent storms and a means of giving more than minutes' warning. (Ronald Nelson)*

tornado are not related, tornadoes have been observed within hurricanes, thus increasing the damage if the total storm crosses a heavily - populated area.

There are many unknowns regarding the birth of hurricanes, just as there are unknowns regarding tornadoes. However, we do know that hurricanes form under considerably different conditions from those of tornadoes. Hurricanes usually generate from some pre-existing disturbance, such as a trough of low pressure in the easterlies, and over the ocean where the water temperature is 80 degrees or higher. Upper level winds and the rotation of the earth play a major role in the development of these huge storms and in giving them a (in the northern hemisphere) counter-clockwise circular motion.

Prefer Hurricanes to Tornadoes

It may be difficult to imagine that Miamians would prefer a hurricane to anything else, but many who were injured, or who lost property during the June 17th blow, told reporters they would rather have a hurricane than a tornado. With modern hurricane warning services, there is usually a two or three day interval in which to board up, take shelter, and otherwise prepare. But a tornado gives only minutes' notice (a noise like a heavy freight train going over a trestle) before it strikes. Many of the injured in

Miami were coming home from the movies or the corner drugstore, with no thought of impending disaster.

Perhaps, as meteorology advances, some accurate means of predicting the time and place of occurrence of a tornado may be devised—at least to the point of enabling radio warnings to be broadcast an hour or two in advance.

However, the problem is a difficult one indeed.

Electric Cable for Tickler

A Dutch fishing trawler owner has developed a new method of electric trawl fishing. An electric cable replaces the tickler chain which is usually attached to the mouth of the standard trawl net and which, by scraping on the sea bottom, serves to scare the fish into the net.

In the new method, the cable produces an electric current in front of the trawl opening. This not only frightens fish into the net more effectively, but also prevents them from leaving the net. In addition, it reduces the load drawn by the trawler, since the electric cable does not actually touch the sea bottom. (See also: "A Shocking Way to Fish!" by C. P. Idyll, *Sea Frontiers*, Vol. 4, No. 2, May, 1958.)

Atlantic Tuna Fishery?

Most of the canned tuna sold in grocery stores originates in Pacific waters. But the Atlantic has its share of these big edible fishes, although the bluefin tuna of the western Atlantic is a little more difficult to catch than the yellowfin sought by Pacific canners. So far the bluefin tuna has only been caught on a small scale for commercial use off the east coast of North America.

As part of a program to develop new resources, the Interior Department's Bureau of Commercial Fisheries has been experimenting with Japanese longline catching methods in the North Atlantic. From the trawler *Delaware* a single heavy line is payed out as the ship steams along. At intervals hooks, baited with frozen herring, are suspended on branch lines. These hooks hang from fifty to 150 feet down, and there may be as many as 1,000 hooks on each longline. One cruise of five days netted more than 33 tons of tuna, some of them weighing as much as 150 pounds.

While experiments have been conducted since 1957, additional research will be necessary before it can be determined whether the big fish are available in sufficient quantity on a year-around basis to warrant the establishment of an Atlantic tuna industry.

THIS AERIAL VIEW *gives a good idea of the excellent arrangement of the buildings and other facilities of the Caribbean Marine Biological Institute, on Curaçao, largest of the Netherlands West Indies. The open Caribbean lies near the bottom of the picture, and Piscadora Bay at the top. The laboratory is the large building (left center); at the right is the guest house. The paved highway leads to Willemstad, capital of the island. (J. S. Zaneveld)*

Probing Caribbean Waters

By JACQUES S. ZANEVELD

Former Director, Caribbean Marine Biological Institute
Curaçao (Netherlands Antilles)

AT THE Caribbean Marine Biological Institute we feel that we are most fortunately situated for the study of tropical sea life and the marine production of the Caribbean Sea, a vast and fertile oceanic region, as yet only occasionally visited by scientists and but fragmentarily known.

Curaçao, where we have our headquarters, is exceptionally well located for both field and laboratory research. Largest of the Netherlands Antilles, the island lies well below the most southerly tracks of hurricanes, and the clear blue waters that surround it literally teem with marine flora and fauna of infinite variety.

Nearby Ocean Deeps

Nearby Los Roques Trench, Bonair Trench, and Curaçao Ridge offer challenging problems in submarine

FOUR HATCHING JARS *are used by the Institute scientists in the study of breeding habits and growth of small marine creatures. Larger animals can be kept in the enclosures at the end of the jetty (center), in Piscadera Bay, where small boats are also moored. (P.M.A. Nooijen)*

geology and hydrography, while much basic investigation of the commercial or food fishes of the area remains to be done.

The Caribbean Marine Biological Institute is a comparatively new station founded in 1955 by the Insular Government of Curaçao. The Lieutenant Governor of Curaçao, Mr. M. P. Corsira, is President of the Board of Trustees. Co-founders include the Foundation for Scientific Research in Surinam and the Netherlands Antilles, the Curaçaose Petroleum Industrie Maatschappij, and the Technical and Economical Council of the Netherlands Antilles.

"Fisherman's Wife" Bay

We did not name the little sheltered bay at our doorstep Piscadera (fisherman's wife), but the name is somewhat appropriate, because this beautiful inlet has always been known in Curaçao for its abundance of fish. Not only do fish abound, but the waters and bay bottom are rich in other marine life, living in a wide diversity of environments.

Most of the time the Caribbean Sea is calm and extremely clear, so that it is possible to carry out field work from a small boat, or with diving gear, down to depths of 150 feet, all the year around. Because mangrove vegetation borders much of the shore, and sea water enters the bay over a sand bar, the ecological or living conditions in the inland bay are quite different from those found in the Caribbean itself.

Plenty of Working Room

The station building, near an old fortress built before 1750, stands partly on a wall of coral shingle, separating the inland bay from the sea, and partly on the adjacent limestone terrace. Less than 75 feet divide it from open salt water.

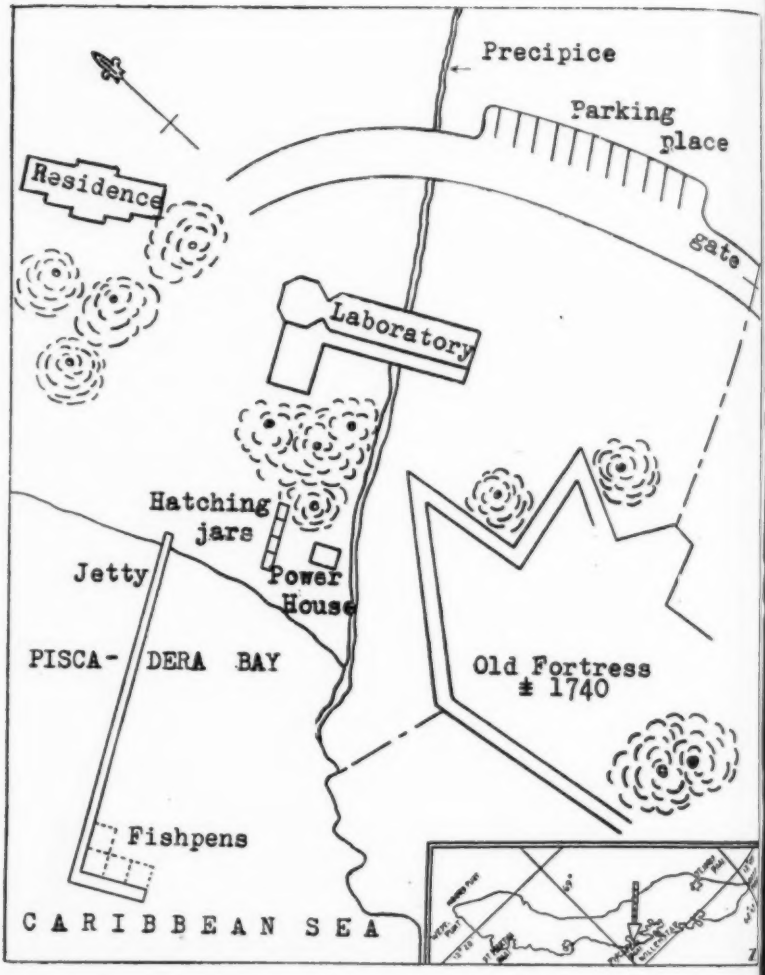
The station fortunately has plenty of working room, with 1,596 square feet of laboratory space, and other facilities adequate for two resident and six visiting investigators, and ten students at one time. The laboratory building has two floors. On the first or ground floor are an octagonal aquarium room, and, adjacent to it, the laboratory and chemico-physical work room. In addition, we have a balance cabinet, workshop and general service room.

The second floor contains an air-conditioned library, the Director's laboratory, three laboratory rooms for visiting scientists, combined auditorium and laboratory, and an air-conditioned photographic darkroom. All apartments on the second floor open on a broad corridor facing the shore. Constant cooling trade winds make this a very pleasant place in which to work.

Sea Water on Tap

As for equipment and facilities, the dust-proof balance cabinet contains an electric semi-automatic micro-

STRANGE TROPICAL FISH *make an attractive live display in the Institute's aquarium. More than 400 species of fish have been identified in the vicinity of Curaçao, evidence of the rich and varied sea life of this part of the Caribbean. (P.A.M. Nooijen)*



balance, and an electric refrigerator for biological purposes is available in the laboratory. Running sea water, fresh water, gas (bottled), air and electricity (110 and 220 volt, 50 cycle A.C.) are available in all rooms of both floors. Portable sea water tables may be installed in the laboratories at any desired place.

Outdoors, between the station and the sea, four hatching jars, or experimental pens, are used in the study of breeding habits and growth of marine creatures. Larger animals can

OLD FORTRESS, *built before 1750, ds near the Caribbean Marine Bio- cal Institute, which dates from 1955. Institute is fortunately situated for study of tropical sea life. As the shows, it lies near the open Carib- n, which teems with sea life, and ts on a sheltered bay where shallow er fishes and coral formations may ily be observed. (Map from author)*

be kept in enclosures at the end of the jetty. A 25 foot, 35 H.P. motor vessel, equipped with nets, seines, aqualung and glass-bottomed buckets, is available for research work along the coasts and bays. By making advance arrangements, a larger boat can be obtained for studies of the little known waters of nearby Aruba, Little Curaçao and Bonaire islands.

Visitors' Research Center

We lay much stress on the fact that visiting scientists and post-graduate students have ample opportunities here to carry on specific research work under actual tropical conditions. The Curaçao Institute is an independent "International Visitors' Research Station," permitting visitors to choose their own projects, and placing at their disposal all the simpler laboratory and field equipment of the Institute at nominal cost.

400 Varieties of Fish

Although the aim of the Institute is to study life in the sea, it is also possible for scientists to study land vegetation, land fauna and the biology of the fresh and brackish water pools and salt lakes of the islands. Adjacent to the station is a residence building, with cooking facilities. Or meals may be obtained at the nearby Piscadera Hotel, or from a restaurant in the city.

As evidence of the rich and varied sea life of this area, more than 400 species of fish have been identified. Caught by single handlines from sailing boats without auxiliary power are dolphin, wahoo, tuna and bonito. Sports fishermen will find tarpon, sailfish, and white and blue marlin, but not as frequently as they will along

FIFTEEN HUNDRED *square feet of working space are provided on the two floors of the main laboratory. There are facilities adequate for two resident and six visiting investigators, plus ten students, at one time. Less than 75 feet separate the laboratory building from open salt water. (M. Arnoldo)*

A LIBERTY PORT *for scientists is Willemstad. It is also the capital of Curaçao. The Caribbean Marine Biological Institute's laboratory and living quarters lie not far from this colorful bit of Holland in the tropics. Across the entrance to the harbor rides a pontoon bridge, called Queen Emma, which must be swung aside each time a ship enters or leaves. (Pan American World Airways)*

the Venezuelan and Panama coasts.

Drift fishing for flying fish, houndfish, balao and goggle-eyed scad is most rewarding in December, January and February. Fishing at anchor is carried on for red snapper, speckled hind, yellowtail, groupers, jewfish, reef-fish and rock hind. Trolling obtains the big game fish, kingfish and tenpounders, and, in shallow water, bonefish and barracuda.

"Splash Zone" Life

In the shallower parts of the sea, zones of animal and algal communities succeed each other from the upper "splash zone," to the various coral regions in the sublittoral and downwards. Gastropoda and other mollusks are very numerous. A recent study of the gastropods found near the shoreline reveals 160 species from the island of Curaçao alone.

Among the cephalopods, the highest class of mollusks, a new species, *Octopus hummelincki,* was described by Adam (1936), and a living specimen studied by Voss (1953). Although the tidal range is only one foot, a good algal zoning may be observed. Among the oddities of the area are the warty, free-lying balls, or *Goniolithon spectabile,* found on a little limestone plateau at the entrance of a large shallow lagoon, on neighboring Bonairex island.

Bizarre Coral

Along the west side of Curaçao, coral reefs form at the northern entrance to the different bays, whereas the gorgonids or soft corals (sea fans, sea feathers and sea whips) abound at the south entrances. The region has

TURTLES ABOUND *in the waters of the Caribbean and the Gulf of Mexico and some grow to huge size. At the Caribbean Marine Biological Institute experiments are being conducted on growth and other characteristics of these sluggish reptiles. This is the tank where turtles are kept while experiments are in progress. (A. de Vries)*

about forty species of coral, including a peculiar orange-red type, *Tubastraea tenuilamellosa,* which grows in a narrow horizontal band just below low tide level.

Dr. L. B. Holthuis, curator of crustacaea at the Rijksmuseum van Natuurlijke Historie, of Leiden, Netherlands, carried out a taxonomic study of the Decapod Crustaceae, finding a total of six species of lobsters. Two of the rarer species, *Parribacus antarcticus* and *Justitia longimana,* were kept alive in the station's aquarium for several months.

Diversity of Life

Much other sea fauna await scientific investigation—crabs, shrimps, sponges and sea urchins, to mention

only a few. Within sponges, for instance, snapping shrimp of the genus *Synalpheus* have been found, and on sea urchins a species of commensal shrimp is quite common and accessible. Fiddler crabs haunt the mud flats.

"Fixed-Anchor Station"

The island of Curaçao actually may be considered a fixed-anchor marine station amid the deeps of the Caribbean. At a distance of only a half mile off the shore, the sea plunges to a depth of 275 fathoms. The deepest spot between Curaçao and Venezuela is about 750 fathoms. Sometimes rare creatures of the depths are caught—the escolar, and, in 1956, the deep water gurnard.

Piscadera Bay, like the other quiet inlets around Curaçao, was a river valley in prehistoric times, and became submerged after the glacial periods. The roots of the bordering mangroves give anchorage to a wide variety of interesting creatures, such as green and brown algae, red sponges, clusters of black ascidians, oysters, serpulids and many colorful sea anemones.

Upside-Down Jellyfish

A large number of jellyfish, *Cassiopea xamachana,* lie on the bottom of the lagoons where sea water percolates through the shingle walls. The peculiarity of this species is that they always rest on the umbrella with the mouth-arms widely spread upwards.

The reason why they lie on their backs is that this particular jellyfish has the unusual and fascinating practice of growing plantlife within its living tissues. The microscopic plant cells are a special algae called zooxanthellae, and need sunlight to live. By reclining on its back the jellyfish

COOLING TRADE WINDS *sweep through a corridor along the first floor, which opens into work rooms making it a very pleasant place to work or to consult with fellow scientists. The second floor contains an air-conditioned library, and laboratories for the Director and visiting scientists. (P.M.A. Nooijen)*

exposes the plants to light. Eventually the jellyfish actually consumes the algae—a sort of internal farming! This may sound bizarre, but it actually occurs here, and in a number of other marine animals, including some flatworms and even corals.

All along Curaçao shorelines mud-retaining algae abound, and delicate colonies of green algae, resembling mushrooms, are found in large numbers on stones and coral pebbles.

Laboratory experiments range from the spawning and raising of fishes in sea water of varying salinity to studies of the resistance of Surinam timber to marine borers.

Field Trip to Islas las Aves

In addition, in 1956, the Caribbean Marine Biological Institute organized a collecting trip to the isolated Venezuelan Islas las Aves, eight miles east of Bonaire. This group consists of horse-shoe shaped small, low cays and numerous coral heads, surrounded by coral reefs. In addition to studies of the geology and marine life of the reefs, bird life was observed, bringing the list of birds known from the Islas las Aves up to thirty-six species, eleven of which are known to breed as well as live there.

The Institute hopes, with the help of visiting scientists and the cooperation of other marine biological and oceanographic organizations working in the same area, to clear up many of the intriguing mysteries of the Caribbean Sea. It is only by such cooperation that our knowledge of this huge ocean basin can be extended, and added to the growing fund of reference material about the seas.

The Ridge that Drowned

In 1779 a Spanish explorer recorded a shoal (bajo) that lay ten leagues off the shore of the Gulf of Alaska. He named it Pamplona, and said it could be seen a mile away. British and Russian traders later reported catching otters on a rocky ledge in the same region. Nearly a century later, however, soundings failed to locate it and Pamplona ridge was removed from all official government charts.

Recently, the U. S. Coast and Geodetic Survey charted a submarine ridge, fifteen miles long, having depths of from 68 to 85 fathoms over its crest, in the same general area. Apparently the original Pamplona sea ridge foundered — that is, its base broke down — and sank 400 feet, some time in the first half of the nineteenth century, demonstrating that the sea floor is not fixed and must be constantly checked.

Science of the Sea in BOOKS

General Reading

SEA DIVER

MARION CLAYTON LINK. Rinehart & Company, Inc., New York and Toronto. 1959. 333 pages; illustrations and maps. $4.50.

Treasure-hunting under the sea is as old as man's earliest efforts to carry valuable objects in boats. But marine archeology, which might be defined as the search for under-water facts rather than material riches, is somewhat newer, although it also involves man's adventuring into a domain in which he can never be fully at home. It remained for an aviation expert, Edwin Link, inventor of the Link trainer for flyers, to evolve marine archeology into a kind of science, using boats equipped with the latest electronic - navigation and salvage gear, metal detectors and diving equipment.

Sea Diver is his wife Marion's thrilling account of adventures shared in the quest of long-lost and nearly forgotten wrecks of Spanish men-of-war, pirate and slave ships, and other victims of war and the elements that strew the reefs off the Florida keys and the islands of the West Indies. Some of their subterranean research throws new light on the landfall of Columbus, which the Links believe was in the Caicos group, south of the Bahamas, rather than San Salvador.

Sea Diver matches a good detective yarn by the manner in which such clues as old cannon, anchors, pewter plates, pieces of eight and other coral-encrusted objects are sought and brought up from the sea bottom, and then, with the assistance of such experts as P. V. H. Weems, retired Navy captain, and Mendel Peterson, of the Smithsonian, identified with marine records and actual historical events. Well written and illustrated, the book has only one fault—it lacks an index. E.J.L.

Technical Reading

MARINE ECOLOGY

HILARY B. MOORE. John Wiley & Sons, Inc. New York, 1958. 495 pp., Illustrated. $9.50.

There has long been a need for a comprehensive and modern reference work on marine ecology, and this Hilary B. Moore has attempted to fill. Great strides have been made since the turn of the century in both field research and methodology in ecology and, while the marine aspect has not, perhaps, kept stride with the land ecology, a voluminous literature has appeared. This volume does not pretend to have covered all of the literature of the subject, and its weakest point is in the German and Russian works, but, for most students of ecology, the bibliography will prove valuable and in some fields complete.

Modern marine ecology is divided, unfortunately, into two opposing camps: that of synecology, the classic approach which studies the community as a whole, and autecology, or the study of the individual species within the community. Synecology has a long history, most of which is confined to descriptive ecology of selected areas. This is an essential step in the study of ecology and is of great importance, but it can also be said, as the autecologists do, that in over one hundred years of synecology, progress in explaining *why* has been disappointingly slow.

In contrast, autecology is comparatively new. Its followers believe that if the ecology of single species is known, this knowledge may then be applied to the community as a whole. In this field, Dr. Moore has long held a prominent position and his studies of certain intertidal and littoral species of Great Britain are familiar to every marine biologist.

It is with this side of marine ecology that this book treats. It is not a text book and makes no pretense of being one. It is a reference work for the advanced student and specialist. General laws, elementary oceanography and related subjects are not found within its covers, but copious references are found in the bibliography.

This reviewer is pleased that the subject is marine ecology and that half the volume is not taken up with subjects that are discussed in full in other standard references such as Sverdrup *et al.* and Allee *et al.* The subject matter is well divided into major headings: Physical Environmental Factors, Biological Environmental Factors, Habitats, Sea Bottom and Continental Shelf, and the Organisms themselves.

There is a paucity of figures of animals, plants and habitats, but there are numerous tables and graphs which greatly enhance the use and value of the volume, and there is a classification at the end treating both animals and plants down to genera, which greatly aids in identifying the numerous scientific names mentioned in the text. The index is comprehensive and permits ready reference to any subject.

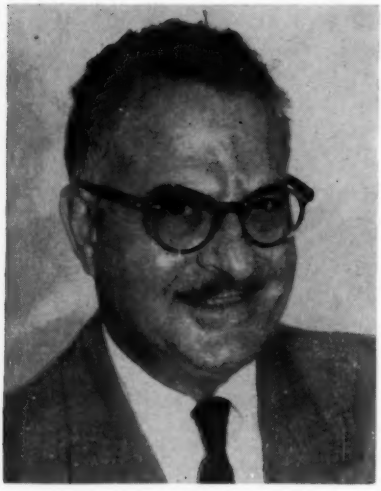
This is an important work and should be in the library of every marine biologist but it is also a controversial book. The synecologists, who greatly outnumber the autecologists, will not like it. Teachers of undergraduate courses will not find in it the general broad laws and axioms upon which they all too often lean. One agrees with the author that as yet we know too little about the ecology of the sea to permit broad generalities which will have not much more truth in them than the Haeckelian generalizations of the late 1800s, the despair of the present day teacher on the higher levels of biology.

Dr. Moore has stated in his Introduction that real advances in ecology will only come when synecology and autecology are wedded in the final phase which he terms "integral ecology." If a general criticism of his book may be given, it is that the author himself, like the missing bridegroom, has failed to arrive at the marriage himself.

G.L.V.

STRANGE AND ABSORBING LIFE *found on a Bermuda coral reef is depicted on the dust jacket of Dr. Moore's "Marine Ecology." It is a valuable reference for the advanced student and specialist, but laymen may find it interesting, too. (John Wiley and Sons, Inc.)*

About The Authors



ARTHUR U. SPEAR

As Information Officer for the State-Federal Screwworm Eradication Program, with headquarters at Sebring, Florida, Mr. Spear found himself involved in one of the most absorbing tasks of his career. A newcomer to Florida in 1957, with more than forty years' experience in newspaper work and creative advertising in his home state of Minnesota, he was appointed publicity director for the Florida State Fair at Tampa during the winter of 1957-58 and joined the eradication program in April, 1958.

DR. RAYMOND M. GILMORE

Dr. Gilmore is one of the leading authorities on marine mammals, and has conducted many investigations of these creatures of the sea in both Atlantic and Pacific waters. As a field zoologist he has also pursued studies afloat and ashore for the University of California, the California Academy of Sciences and the American Museum of Natural Science. Between 1944-46, Dr. Gilmore was associate curator of mammals, U. S. National Museum, Smithsonian Institution, Washington, D. C.

More recently he has conducted whale investigations for the U. S. Fish and Wildlife Service, Department of the Interior, Washington, D. C., and La Jolla, Calif. His present position is research curator of marine mammals, San Diego Natural History Museum, San Diego, Calif.

Dr. Gilmore obtained his A.B. and M.A. in zoology at the University of California, and his doctorate in zoology at the University of Cornell. In 1934-35 he was a Virginia Biggs Fellow at Harvard. His interest in the fate of the West Indian seal is typical of a long standing concern for the conservation of sea mammals, and a belief that, by presenting all the known facts, someone may come up with a clue that would help to restore nature's balance, in which all living things play a part.

T. R. GOEDICKE (ABOVE)

As the son of a consulting engineer for a large American chemical company, Dr. Goedicke travelled extensively even in his early youth, attending public and

high schools in such widely separated places as Seoul, Koreo; Tokyo, Japan, and Munich, Germany. He also acquired a love for the sea from his father, a devoted yachtsman, who taught the rudiments of sailing to his son at the age of eight. Since then sailing and photography have been the hobbies of much of his leisure time.

Study at McGill University was followed by geophysical exploration in northern Canada. Postgraduate work in geological engineering at North Carolina State and the University of North Carolina finally led to a doctor's degree at the Polytechnical University of Munich, Germany. At Texas A.&M. he held an assistant professorship in geophysics and geology.

Meanwhile Dr. Goedicke had begun his studies of the structures of the continental shelf by analysis of the salt-dome origin of the pinnacles off Galveston, Texas. More recently, he has done research on new methods and techniques in geophysics, and has obtained several patents in this field. Investigation of the marine oil resources of the world resulted in a preliminary study presented at the Twentieth International Geological Congress, and further work will be incorporated in a book.

Dr. Goedicke participated in the geophysical work during the recent exploration of the earth's crust north of Puerto Rico on board the research ship *Hidalgo*.

JACQUES S. ZANEVELD

Dr. Zaneveld became interested in marine matters early in life. He was born in that famous Netherlands seaside resort and fisheries center with the utterly unpronounceable (for outsiders) name of Scheveningen. But his knowledge of biology he obtained at Leiden University, and of marine biology at the Dutch Zoological Station, den Helder.

In pursuit of his special interests, intertidal organisms and marine algae, Dr. Zaneveld has left his footprints along the beaches of Europe, Indonesia, the East Indies, Canada, the United States, and the Netherlands West Indies. In May, 1955, he was appointed the first director of the Caribbean Marine Biological Institute. His primary interest outside of marine biology is the Boy Scouts, having served as Chief Scout of Indonesia 1949-51, and of the Netherlands from 1953-55. He still holds warrants as Deputy Camp Chief for Scouts and Rovers of the Boy Scout International Bureau, Canada.

In September 1959, Dr. Zaneveld accepted a position as Professor and Head of the Biology Department of the College of William and Mary, Williamsburg, Va.

Progress

DURING THE FEW YEARS of its existence *Sea Frontiers* has reached a membership which has more than doubled every twelve months. Members are drawn from the United States, Canada, Central and South America, Great Britain, Australia, France, Germany, Italy, Turkey, Denmark, Sweden and Norway as well as a few from the Pacific Islands, the West Indies and Russia.

CONTINUED IMPROVEMENT will be possible with growth of active membership. It will be seen in better service, with more articles in the magazine of high interest and authenticity and, eventually, a monthly issue in full color.

IN ADDITION TO PUBLISHING *Sea Frontiers* and *Sea Secrets,* the Foundation provides active support for scientific research and education. The ocean is our last frontier and its exploration still under way.

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"To encourage the extension of human knowledge by scientific study and exploration of the oceans in all their aspects, including the study of game fishes, food fishes, ocean currents, the geology, chemistry, and physics of the sea and the sea floor."

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Qualifications for membership are an interest in the oceans and a desire to extend and develop scientific research and exploration into them. Support given to research through personal activities or donations is recognized by the Foundation through the following classes of membership. Members are those who make annual contributions of $5, Fellows $25 annually; Associates $100 annually; Life Fellows are those who contribute $200 or more or who have otherwise helped to advance the purposes of the Foundation; Sponsors who contribute $1,000 or more; and Patrons who contribute $5,000 or more. Corporate Associates contribute $1,000 annually.

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